Epidemiological Study of Cancer and Other Chronic Diseases

MONOGRAPH 19

NATIONAL CANCER INSTITUTE MONOGRAPH 19

January 1966

Epidemiological Approaches to the Study of Cancer and Other Chronic Diseases

Editor: William Haenszel

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

PUBLIC HEALTH SERVICE

NATIONAL CANCER INSTITUTE, BETHESDA, MARYLAND

NATIONAL CANCER INSTITUTE MONOGRAPHS

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Harold F. Dorn
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FOREWORD

The death of Harold Dorn in May 1963 brought to a close a productive and distinguished career in demography, medical statistics, and cancer research. His many achievements were set forth in obituaries written at the time and there is no need to recite them here. The editors of the *Journal of the National Cancer Institute* believed it would be fitting to recognize Dorn's contributions by the issuance of a monograph reporting on work related to the epidemiology of cancer and cardio-respiratory diseases, fields that had engaged his interest and attention. In accepting the invitation to edit this monograph I was guided by one criterion: Manuscripts should present new data and discuss substantive issues.

Most of the monograph has been devoted to the presentation of findings from prospective studies. Dorn was one of the first to apply this technique on a grand scale to cohorts with members numbered in the hundred thousands. His observations on mortality among Government Life Insurance policyholders, begun in 1954 with the cooperation of the Veterans Administration, was one of the three large prospective studies initiated early in the 1950 decade with the intent of investigating the effects of smoking on health. The first results of surveillance of the policyholders were published by Dorn, and follow-up continued under his direction. Analysis of the accumulated data for 8½ years has been completed in time for inclusion in this volume.

Prospective studies have become more feasible in recent years due to improved data collection and data management procedures, but they call for expensive commitments in terms of financial support, study time, and staff. They still pose problems in methodology and interpretation of results which were of concern to Dorn. Resolution of these questions is the subject for future work, which will require collation of data from several study sources. Investigators reporting the results from prospective studies are often embarrassed by the wealth of detail at their disposal, which no conventional editor concerned with optimum utilization of journal space would permit them to publish. Such editorial practices, while logical and understandable in any isolated instance, have foreclosed opportunities for comparative reviews of the empirical evidence available from the several studies. These considerations suggested that the monograph could advance the objectives stated, through publication in a single volume of data from other ongoing studies. Richard Doll and Sir Austin Bradford Hill, and Cuyler Hammond graciously responded to the invitation to contribute papers dealing with selected aspects of their studies. I encouraged them to describe their detailed findings in appendix tables which, I believe, represent a unique data resource worthy of study by other investigators and useful for the teaching of students. Is there a better way to pay tribute to a man than by publication of a volume which can serve as a reference for years to come?

The monograph provided an appropriate solution to a dilemma concerning authorship of papers reporting more extensive data from the study of Government Life

Insurance policyholders. At the time of his death Dorn had not returned to detailed examination of the results nor had he drafted plans for their publication, tasks assumed by one of his associates, Harold Kahn. To attach Dorn's name posthumously to a paper he did not write and for which he did not bear direct responsibility for the contents would have violated a standard to which he had steadfastly adhered in life. The title of Kahn's paper and its appearance in this volume give adequate testimony of Dorn's role, but responsibility for the paper and for statements or conclusions expressed therein, following usual scientific practice, remains with the author.

The set of three papers on plans for the investigation of cardiorespiratory diseases and cancer among British and Norwegian migrants to the United States represent perhaps a more sophisticated and complex application of survey and prospective study methods for assessment of the roles of host characteristics and environmental factors in the determination of levels of risk for specific diseases. Planning of these studies had occupied much of Dorn's time in the 2 years preceding his illness and death.

Pursuit of the epidemiology of chronic diseases calls for a variety of study tools and the synthesis of data from several sources. Other papers in this volume report on a case-control study of radiation exposure effects, reconciliation of incidence data from cancer registers and morbidity surveys, the use of pathology protocols to elaborate findings suggested by vital statistics and cancer register data, and refinement of tabulations of mortality data to take advantage of more of the diagnostic information provided by the certifying physician. The reader will recognize that the authors address themselves to questions raised by Dorn or have been stimulated by his published findings and comments.

In editing the papers, I have been impressed by their timeliness and relevance to other work. Although they have been included because of some connection, close or tenuous, with Dorn, they may also be regarded as a fair sample of the present state of chronic disease epidemiology. While reservations may be expressed as to whether cancer epidemiology specifically has achieved its full potential, one cannot deny from the perspective of the past 30 years that advances have been made. Prior to the 10-city cancer morbidity surveys in 1937, knowledge about the distribution of cancer risks in man was rather limited. Compare what we now know with the information at the disposal of Schereschewsky, Gover, and other investigators of a preceding generation. No one man, not even Harold Dorn, is responsible for all the recent advances in this particular field. However, the record will show that he was in the vanguard of his contemporaries when cancer epidemiology was beginning to flourish.

The picture of Harold Dorn in this volume was selected by Mrs. Dorn. In preference to a formal portrait, she chose one showing him in a more typical pose as a working investigator in shirt sleeves. The picture was taken in October 1952 at the laboratory of Professor Alfred Kinsey at Indiana University.

William Haenszel

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The Dorn Study of Smoking and Mortality Among U.S. Veterans: Report on Eight and One-Half Years of Observation [1, 2]

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INITIATED by Dorn in 1954, the study of a group of U.S. veterans was one of the first three large prospective investigations undertaken to describe in detail the relationships between tobacco use and mortality experience. Two features made this study of special interest. One was the precise definition of the population, which permitted identification and follow-up of both respondents and nonrespondents, and the other was its size. The Doll and Hill (*5*) study of British physicians, begun in 1951, was based on a defined population of 59,600 men and women. The Hammond and Horn (*13*) study of 188,000 men, begun in 1952, was large in scale, but lacked the element of population definition. The Dorn study was concerned with a defined population of over 293,000 holders of life insurance policies.

The study population and plan have been set forth in detail in two publications (*7*, *8*). Some major features are summarized below. With the cooperation of the Veterans Administration, policyholders of U.S. Government Life Insurance were selected for study. This insurance was available to persons who served in the armed forces of the United States from 1917 to 1940. Most of the policyholders were veterans of World War I; the remainder entered military service at a later date. The cohort comprised 293,658 persons who held active U.S. Government Life Insurance policies in December 1953. Beginning in January 1954, questionnaires on smoking habits (appendix E) were mailed to these policyholders, with 198,834 (68%) responding. Beginning in January 1957, a second questionnaire, essentially identical to the first except for typography, was mailed to those not responding in 1954, which elicited

[1] National Institutes of Health, Public Health Service, U.S. Department of Health, Education, and Welfare.

[2] This study was made possible through the cooperation and assistance of the Veterans Administration.

[3] Mr. James W. Gilliss and Mr. Felix Liski of the Computation and Data Processing Branch, National Institutes of Health, were responsible for maintaining the basic punch card records for many years. Mr. Jon A. Halverson, Mr. Gary D. Knott, and Mr. Paul Kowalowski of the National Institutes of Health Computation and Data Processing Branch, in cooperation with Mrs. Jeanne T. Truett of the National Heart Institute Biometrics Branch, translated the author's requests for tabulations into programs, test runs, checking procedures, and the final product. Mrs. Betty L. Carter and Mrs. Josphine E. Maxwell managed the complex clerical procedures required in the study office and Mrs. Mary Fanfani provided both accuracy and continuity in coding of mortality data.

49,361 additional replies, raising the response rate to 85 percent. All smoking classifications used in this report are taken directly from information supplied in these questionnaires.

CHARACTERISTICS OF THE POLICYHOLDERS

Almost all policyholders were white males. Less than half of 1 percent were females, and only a negligible number were nonwhite males. Eighty-two percent were white-collar or skilled workers, 7 percent were semi-skilled or unskilled workers, and 6 percent were farmers or farm laborers. Roughly comparable percentages for U.S. white males aged 20 to 54 years as of the 1950 Census were 50, 35, and 13, respectively (*19*). Clearly, semiskilled and unskilled workers were underrepresented in the study population; such selection is found in the experience of all insurance companies writing whole-life or endowment policies.

Since the policyholders were drawn mainly from the middle and upper socioeconomic classes, it could be anticipated that their death rate from all causes during the period of observation would be less than that for the general white male population (*12, 23*). Mortality in the study population age 55 to 84 (respondents and nonrespondents) expressed as a proportion of the mortality for U.S. white males of like age composition was 0.75 for the interval July 1954 to June 1957, 0.73 (July 1957–December 1960), and 0.67 (1961–62). An estimate of the number of death reports for 1961–62 not received until after the cutoff date for the present tabulations suggests that the true figure for the 1961–62 period is closer to 0.71. Pending the receipt of more complete data on deaths it seems reasonable to estimate the mortality of the population of insured veterans during the initial 8½ years of observation as about 0.73 of the corresponding U.S. rate. Judgments on the presence of a real and sustained improvement in mortality over time among policyholders relative to the U.S. white male population should be deferred until sufficient time has elapsed to ensure that all delayed death notifications for the more recent years have been received.

FOLLOW-UP

Additional follow-up procedures over and above the normal Veterans Administration routine were required which were carried out by the staff at the National Institutes of Health. Whenever a claim is filed for the payment of a policy, a copy of the death certificate is routinely sent by the Veterans Administration to the NIH study office. Annually the Office of the Chief Actuary in the Veterans Administration also provides a deck of punch cards for each policy terminated during the year, indicating whether termination was due to death or other reasons. The cards for policies terminated by death serve as a check on the completeness

of reporting of deaths. Records without death certificates are traced through appropriate VA offices and the missing data ultimately obtained. Veterans may, of course, have more than one U.S. Government Life Insurance policy and, when a notice of policy termination for reasons other than death is received, a check is made to determine whether the individual has any remaining active policies. If not, the record is transferred to a special file for "terminations" and periodically the Veterans Administration Index Section is asked to report whether these individuals are still living. If not, a letter, requesting a copy of the death certificate, is then written to the VA office having custody of the records. Termination of insurance means an automatic notification procedure for reporting death has been lost, but the VA has so many other points of contact with beneficiaries (including payments to defray funeral expenses) that mortality follow-up on "terminations" is considered to be quite satisfactory for inclusion in this study. Although very good, it would be unrealistic to assume that mortality reporting on "terminations" is as complete as for active policyholders. Therefore, it is of interest to investigate whether the termination rates are the same for smokers and nonsmokers and this point will be considered in a later section. All mortality follow-up procedures apply identically to respondents and nonrespondents, so that the study findings can be related to the insurance policyholders as defined and need not be restricted to the subgroup who answered the smoking questionnaire.

When a death certificate is received, additional medical information including verification of statements on causes of death is requested from the certifying physician or the hospital where death occurred. The data reported here reflect the composite information available from the query and the original death certification. In about 6 percent of the deaths the query led to a change in assignment of the underlying cause, and in another 12 percent information on contributory causes not mentioned in the original certification was added, though the underlying cause remained unchanged. The underlying reason and as many as two additional contributory causes were routinely coded for all deaths.

METHOD OF ANALYSIS

The available data were summarized into the number of deaths, d_x, and the number of person-years of observation, y_x, at each single year of age from 35 to 84. Person-years were accumulated by attained age and *not* by a fixed age determined for each individual as of the start of the study. The ratio d_x/y_x provides an estimate of the average annual force of mortality at age x, $\mu_x = \int_x^{x+1} \mu_t dt$. Person-years are terminated in the middle of the month of death and the values of d_x/y_x could exceed unity at the oldest ages. The actuarial formula relating force of mortality and probability of death within the period x to $x + 1$ can be written as

$$q_x = 1 - \exp - \int_x^{x+1} \mu_t dt \tag{16}$$

and the estimated annual probability of death at age x, q_x, computed from the equation

$$q_x = 1 - \exp - d_x/y_x.$$

The q_x values for individual years of age for the different smoking classes were calculated in this manner and then averaged into 10-year age groups 35 to 44, 45 to 54, 55 to 64, 65 to 74, and 75 to 84, with the 1960 distribution of the U.S. male population by single years, within the corresponding 10-year age group, used as weights. The study population is such that ages 55 to 84 represent about 98 percent of the deaths and about 85 percent of the person-years. Therefore, several of the tables dealing with detailed smoking categories omit age-specific data for ages under 55.

In addition to the age-specific probabilities, a mortality ratio of the number of observed to expected deaths was computed for each smoking category. The expected number of deaths for each smoking category was computed as the product of the person-years of observation at age x in that category by the force of mortality at age x for those who never smoked, summed over ages 35 to 84 inclusive. This is equivalent to stating how many would have died in a subgroup of smokers if the force of mortality observed among nonsmokers prevailed. The force of mortality, μ_x, was used rather than the probability of death, q_x, to ensure that the expected number of deaths for nonsmokers would exactly equal the observed number. Throughout this report the terms "nonsmoker" or "never smoked" are to be understood as including persons who have never been regular smokers but who may have smoked occasionally.

The mortality ratio is a relative indirect age-adjusted rate and as such is a function of the age structure of the smoking category being adjusted. For this reason it is technically incorrect, though the practical effect is often negligible, to compare directly the mortality ratio for *smoking* category A with that for another *smoking* category B, since the differing age structures of A and B are not controlled in this comparison. Of course, all mortality ratios are comparable to the base experience for nonsmokers which is defined to be 1.00. The mortality ratio is a convenient summary index, but wherever its use leads to a different inference than that derived from a direct ratio of age-specific rates, the latter is always to be preferred, subject only to the limitations of larger sampling errors associated with smaller subsets of the data.

Because of the large number of deaths (6,932) and person-years of observation (443,856) available to estimate the force of mortality for nonsmokers, all references to sampling variability of mortality ratios incorporate the simplifying assumption that the expected number of deaths was determined with so little error that sampling variability of the latter can be ignored. Given this assumption, the variability of any mortality ratio depends solely on the random sampling error in the observed

number of deaths. Unless otherwise specified, all tests of significance are at the 1 percent level.

PRESENT REPORT

The present report includes all deaths known to us, ages 35 to 84 inclusive, occurring from July 1954 through December 1962. Table 1 distributes the 46,270 deaths and the 2,265,674 person-years observed during this period by age and respondent status. The second questionnaire to nonrespondents in 1954 was mailed in January 1957 and for the next several months, while replies were being received, the probability of response was strongly associated with current health. In order not to exaggerate any differences in mortality between respondents and nonrespondents, July 1957 was chosen as the date for transferring individuals from nonrespondent to 1957 respondent status. Thus, someone who answered the second questionnaire in March 1957 and died in May 1957 was treated entirely as a nonrespondent. A person who replied in March 1957 and died in August 1957 was counted as a nonrespondent from July 1954 through June 1957 and as a 1957 respondent thereafter, and his death counted in the 1957 respondent category.

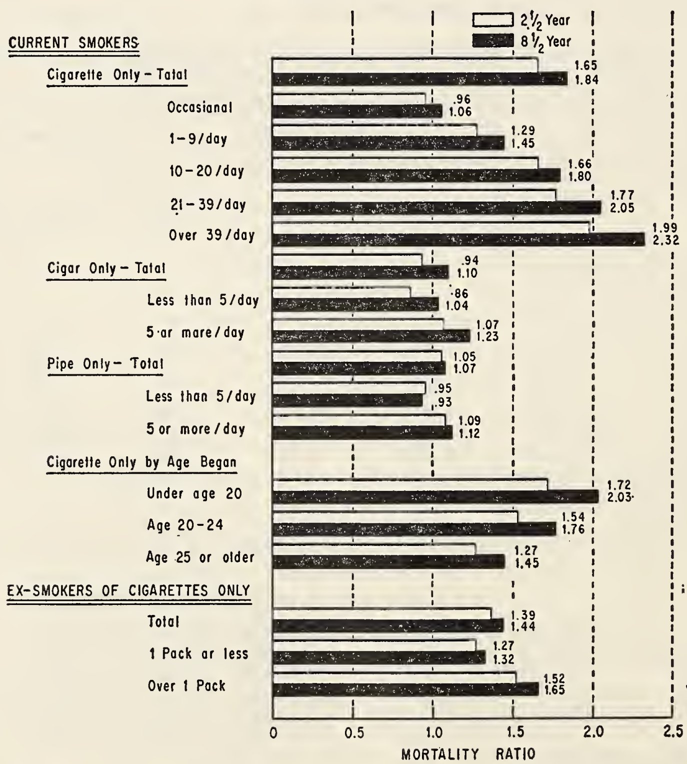
TABLE 1.—Distribution of deaths and person-years of observation by attained age and response status, July 1954–December 1962

Years	Grand total	Respondents			Nonrespondents	
		Total	1954	1957	Number	Percent of grand total
Deaths						
35–84	46, 270	35, 691	29, 731	5, 960	10, 579	22. 9
35–44	559	389	302	87	170	30. 4
45–54	532	374	322	52	158	29. 7
55–64	19, 523	14, 414	12, 528	1, 886	5, 109	26. 2
65–74	23, 107	18, 454	14, 877	3, 577	4, 653	20. 1
75–84	2, 549	2, 060	1, 702	358	489	19. 2
Percent of deaths with inadequate information on smoking habits		4. 5	4. 9	2. 8		
Person-years						
35–84	2, 265, 674	1, 801, 119	1, 547, 805	253, 313	464, 555	20. 5
35–44	251, 122	193, 725	159, 661	34, 064	57, 397	22. 9
45–54	87, 985	70, 787	60, 099	10, 688	17, 198	19. 5
55–64	1, 124, 385	868, 546	776, 187	92, 359	255, 839	22. 8
65–74	765, 933	637, 082	525, 676	111, 405	128, 851	16. 8
75–84	36, 249	30, 979	26, 182	4, 797	5, 270	14. 5
Percent of person-years with inadequate information on smoking habits.		4. 6	4. 9	2. 7		

MAJOR RESULTS FROM INITIAL PERIOD (2½ YEARS) COMPARED WITH EXTENDED PERIOD (8½ YEARS)

Dorn reported the findings from the initial 2½ years of observation (*7, 8*). Data from this study have also been extensively cited in *Smoking and Health* (*22*).

Text-figure 1 presents an over-all comparison of mortality ratios for all causes of death by smoking category for the two time periods. For each class of smokers (except for one pipe-smoking category) the mortality ratios based on the total observation period were larger than those derived on first review and analysis. We will return to this point in some detail in a later section dealing with possible extent of selection bias, but some comments seem appropriate here. There are two major differences between the study periods. Coverage of persons in the first 2½ years was limited to those who answered the 1954 questionnaire. The 8½-year period includes data for both 1954 and 1957 respondents. In the earlier reports, observation was terminated on persons who no longer held active insurance policies, but the data for the 8½ years include both person-years and deaths experienced after termination dates. Despite these and other differences to be discussed under the heading Selection Bias, the corres-

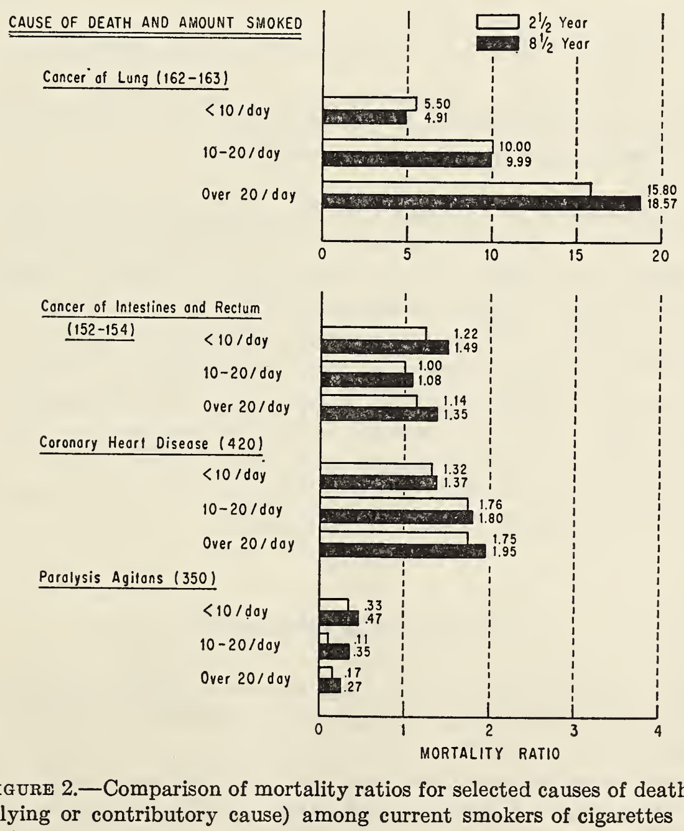


TEXT-FIGURE 1.—Comparison of mortality ratios for all causes of death by smoking category—2½- and 8½-year follow-up.

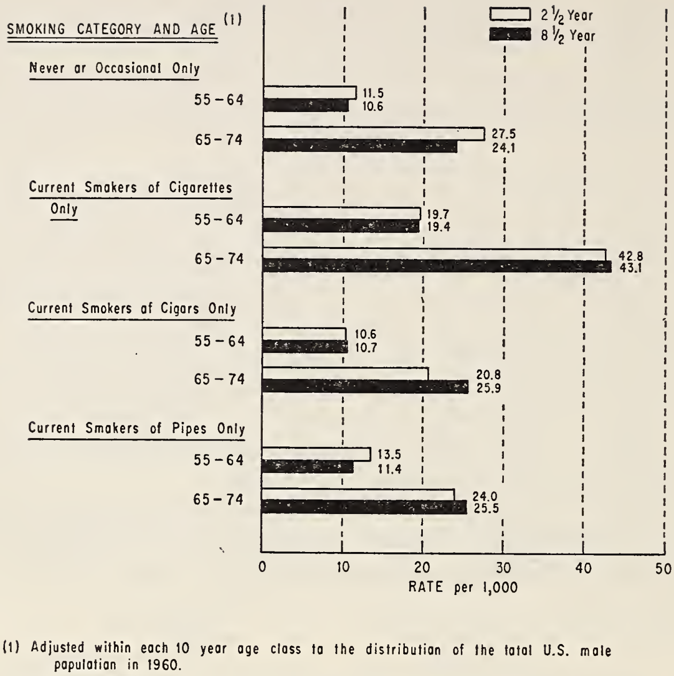
pondence in mortality ratios based on the preliminary and extended observation periods is striking and impressive. Thus, both sets of results show a strong positive gradient with number of cigarettes smoked, a negative gradient with age began smoking, lower mortality ratios for ex-cigarette smokers than for current smokers, and much lower mortality ratios for cigar and pipe smokers than for cigarette smokers.

Text-figure 2 contrasts the two periods with respect to mortality ratios for selected causes of death. They were chosen for illustration from the disease with the strongest association with smoking history (lung cancer), a disease with no risk gradient by amount smoked (cancer of intestines and rectum), the disease with the largest number of "excess" deaths associated with smoking history (coronary heart disease), and the disease with the smallest mortality ratio (paralysis agitans). The estimated ratios from the 8½ years tend to run somewhat higher, but the structure of relationships is again very consistent. All the original findings have been confirmed by more extended observation.

Text-figure 3 compares annual death rates for the 2½-year period with the annual probabilities of death calculated for the 8½-year period. At the observed level of mortality experience, the two techniques for meas-



Text-figure 2.—Comparison of mortality ratios for selected causes of death (includes underlying or contributory cause) among current smokers of cigarettes only—2½- and 8½-year follow-up.



TEXT-FIGURE 3.—Comparison of annual death rate per 1,000 (2½-year follow-up) with the annual probability of death per 1,000 (8½-year follow-up). All causes of death by smoking category for ages 55–64 and 65–74.

uring risk are essentially equivalent and any understatement in the probability of death in relation to the death rate is unlikely to exceed 2 percent. The measures of mortality for cigarette smokers are almost identical for both periods, and no striking differences can be discerned for the cigar and pipe categories. The more extensive observations yield somewhat lower estimates of risk for nonsmokers, particularly at ages 65 to 74. Differences between time periods are small compared to differences among smoking classes. While the two sets of data lead to the same inferences, the longer observation period provides an opportunity for a more precise look at various relationships. The following sections present and discuss in more detail the results for the 8½-year period.

SMOKING CATEGORY

Mortality ratios by smoking class are shown in table 2; supplementary detail on number of deaths and age-specific probabilities of death are given in Appendix tables A and B.

Current smokers of cigarettes have mortality ratios directly related to the amount smoked. This statement holds true for smokers of cigarettes only and for all smokers who combine the use of cigarettes with other

TABLE 2.—Mortality ratios* by smoking category, July 1954–December 1962

Smoking category	Current smokers	Ex-smokers	
		Stopped on doctor's order	Stopped for other reasons
Cigarette—total	1. 71	1. 95	1. 27
Occasional	1. 18	—	—
1–9/day	1. 31	1. 78	1. 08
10–20/day	1. 68	1. 92	1. 21
21–39/day	2. 00	1. 87	1. 47
39+/day	2. 32	2. 47	1. 58
Cigarettes only—total	1. 84	2. 05	1. 35
Occasional	1. 06	—	—
1–9/day	1. 45	—	1. 15
10–20/day	1. 80	1. 97	1. 28
21–39/day	2. 05	2. 02	1. 53
39+/day	2. 32	2. 67	1. 60
Cigars only—total	1. 10	1. 80	1. 26
1–4/day	1. 04	—	1. 17
5–8/day	1. 17	—	1. 21
9+/day	1. 49	—	1. 75
Pipes only—total	1. 07	1. 81	1. 20
1–4/day	0. 93	—	1. 18
5–19/day	1. 10	—	1. 18
20+/day	1. 20	—	—

*Not shown if less than 50 deaths observed.

forms of tobacco. Persons who smoked two packs of cigarettes per day or more had 2.3 times the mortality risk of nonsmokers. The gradient of risk with amount smoked is slightly steeper now than first estimated from 2½ years of observation.

A gradient in mortality risk with amount smoked also appeared for cigar and pipe smokers. Both moderate (5–8 cigars or 5–19 pipes) and heavy (9 or more cigars or 20 or more pipes) smokers of cigars and pipes have mortality ratios significantly greater than 1.00. Those who currently smoke only 4 cigars or pipes or less per day have mortality ratios not significantly different from nonsmokers. Thus, current users of cigarettes, cigars, or pipes experience excess mortality risks if they smoke more than an occasional cigarette or more than 4 cigars or pipes per day.

In an effort to minimize a presumed artifact in the data for ex-smokers, mortality ratios were calculated separately for two groups of ex-smokers. Those who stopped on doctor's orders experience consistently higher risks for all causes than those stopping for other reasons. By segregation of the former component (about 10% of all ex-smokers), analysis of the experience of ex-smokers can be partially freed from the distortion introduced because illness was the reason for stopping (*14, 15*). Whereas it is difficult to gauge the credence to be accorded a reported reason for an action, separation of these groups is a step in the right direction. About 5 percent of the records are coded "reason unknown" and these have been included with "other reasons." Unless otherwise specified, further

reference in this paper to ex-smokers will be restricted to those who stopped for reasons other than doctor's orders.

Among ex-cigarette smokers mortality ratios in each subclassification recede to an intermediate position between the corresponding figure for current smokers and nonsmokers. In the process a gradient in risk by number of cigarettes formerly smoked is maintained. However, former cigar or pipe smokers have higher mortality ratios than those who continue smoking. When Dorn first reported this rather curious finding (*7*) he stated that "many cigar and pipe smokers may have stopped smoking because of ill health, but it is not obvious why this should be true for cigar and pipe smokers but not for cigarette smokers." It is certainly not obvious why such an effect should persist among cigar and pipe smokers after excluding those who stopped smoking because of doctor's orders.

In summary, for each form of tobacco use, mortality risk is directly related to amount smoked. The risks for cigarette smokers greatly exceed those for cigar or pipe smokers and are lower for those who have stopped than for those who continued smoking. A gradient of risk according to amount smoked is evident.

AGE BEGAN AND NUMBER OF YEARS SMOKED

Table 3 contains mortality ratios computed for current smokers of cigarettes cross-classified by amount smoked, age began, and number of years smoked. Discussion of these variables will be limited to cigarette smokers because of insufficient data for analysis in the categories of pipe or cigar smokers subject to excess risk.

Among those who began at age 20 or later, the relationship of years smoked to risk depends on the amount smoked. Those who smoke 1 to 9 cigarettes a day do not display a significantly higher risk than nonsmokers until 25 years or more have elapsed. Smokers of 10 to 20 cigarettes a day experience a significantly greater risk after 15 years. Not shown in the table because it was based on only 48 deaths is a ratio of 1.66 for smokers of 21 to 39 cigarettes who started at age 20 or later and smoked for less than 15 years. (Other cells omitted from table 3 are based on 16 deaths or less.) This ratio of 1.66 is significantly greater than 1.00 and would suggest that persons who attain a rate of over a pack a day may be subject to increased risk in less than 15 years. Among those who began smoking before age 20, the results do not strongly indicate that mortality risks continue to rise with longer duration of exposure. Once a significantly higher risk is reached there is little evidence of further increases. One may reserve judgment as to whether this apparent plateau in risk correctly reflects the facts or whether the very great overlap among duration categories has blurred beyond recognition an association with duration of exposure. The duration categories <15, 15 to 24, 25 to 34, and 35+ are those reported on the smoking questionnaire. Since the present report covers 8½ years, the actual durations to which these labels now

apply are <23½, 15 to 32½, 25 to 42½, and 35+. With this overlap a gradient in risk with longer durations of exposure might well be obscured. Future tabulations of these data might profitably incorporate an up-dating of the intervals for duration of smoking which would be based on the assumption of persistence in reported smoking habits.

For each category of smoking duration for which data suffice to make a comparison, persons who began smoking cigarettes under age 20 are at greater risk than those who started later. The difference is quite noticeable, particularly for the heavier smokers. Since control for smoking duration has been introduced in these comparisons, the extra risk associated with an early age of onset cannot be attributed solely to longer exposures. Possibly, those who began smoking at an early age include a higher proportion of inhalers or deep inhalers than persons starting to smoke cigarettes after age 20. However, no data from this study can be presented to support this hypothesis, since the questionnaire on smoking habits did not cover this item.

Although data are inadequate with respect to the shorter durations of smoking habits among those who started before age 20, the over-all pattern of mortality suggests a relationship with total exposure time and dose, with a strong indication that the manner of exposure (the observational counterpart of the dosage schedule in an experiment) is also important.

A recent report (*9*) suggesting that coronary disease mortality risk associated with cigarette smoking might be a very short-term effect unrelated to duration is difficult to check in the manner described above for total mortality because of the reduced number of observations. Table 3a is an abridged version of table 3 for mortality from coronary heart disease (CHD), but is not restricted to ratios based on 50 or more observed deaths.

TABLE 3.—Mortality ratios* by number of years smoked and age began, current smokers of cigarettes, July 1954–December 1962

Number of cigarettes per day	Age began	Number of years smoked			
		<15	15–24	25–34	35+
1–9	<20	—	—	—	1. 45
	20+	0. 94	1. 04	1. 13	1. 32
10–20	<20	—	1. 74	1. 67	1. 79
	20+	1. 04	1. 42	1. 44	1. 67
21–39	<20	—	2. 03	2. 87	2. 18
	20+	—	1. 54	1. 61	1. 82
39+	<20	—	—	—	2. 55
	20+	—	—	1. 90	2. 05
Total 1 or more/day	<20	—	1. 88	2. 21	1. 92
	20+	1. 10	1. 34	1. 44	1. 66

*Not shown if less than 50 deaths observed.

The data for CHD could be construed as compatible with the gradient reported for total mortality by number of years smoked, if one is willing to accept the two largest nonsignificant ratios (1.75 and 1.44 for 21–39

TABLE 3a.—Mortality ratios* for coronary heart disease by number of years smoked, current smokers of cigarettes who began at age 20 or later, July 1954–December 1962

Number of cigarettes per day	Number of years smoked			
	<15	15–24	25–34	35+
1–9	*1.13* (36)†	*1.37* (43)†	*1.10* (112)†	1.20 (273)†
10–20	*1.18* (41)	1.46 (95)	1.48 (364)	1.63 (988)
21–39	*1.75* (19)	*1.44* (39)	1.70 (215)	1.60 (465)

*Ratios not significantly different from 1 (P <0.01) are shown in italics.
†Number of deaths observed in parentheses.

cigarettes) as approximate estimators of risk. The lack of correlation with duration is such that the ratio of 1.18 observed for smokers of 10 to 20 cigarettes for less than 15 years constitutes the one exception to an almost perfect fit of the data with a hypothesis of no relationship to duration. From this example one can appreciate how even smaller study populations may yield, through sampling variations, conflicting statements on the relationship of CHD mortality risks with duration of smoking.

In summary, there appears to be a relationship between smoking duration and risk of death from all causes for at least certain smoking classifications. Whether a parallel relationship also holds for the subgroup of deaths from coronary heart disease remains uncertain.

AGE-SPECIFIC MORTALITY RATIOS

The mortality ratios presented in the preceding sections are summary averages of the relative position of smokers *vis-a-vis* nonsmokers over the age span 35 to 84 years. Table 4 gives a more detailed account of the mortality ratios for ages 55 to 64, 65 to 74, and 75 to 84; ages under 55 have been omitted because of the few deaths observed among nonsmokers in these groups. Among the several categories of smokers of cigarettes only, the relative advantage in mortality from all causes among nonsmokers diminishes with age. This feature is most evident in the contrast of age 75 to 84 with 65 to 74. The presence of a similar age relationship in mortality ratios for pipe and cigar smokers cannot be demonstrated with the data now in hand.

CLASSIFICATION BY AMOUNT SMOKED

Table 5 considers the mortality ratios for several categories of current smokers derived from classification according to current amount and maximum amount ever smoked. The correspondence in numerical values for mortality ratios generated by the two classification schemes can be regarded as good in most instances, though the small differences are

TABLE 4.—Age-specific mortality ratios* for current smokers, July 1954–December 1962

Current smoking category	55–64	65–74	75–84
Cigarette only—total	1. 84	1. 79	1. 54
Occasional	1. 08	1. 05	—
1–9/day	1. 36	1. 48	1. 29
10–20/day	1. 75	1. 75	1. 58
21–39/day	1. 98	2. 05	1. 61
39+/day	2. 59	2. 32	—
Cigar only—total	1. 01	1. 08	1. 03
1–4/day	0. 89	1. 00	1. 03
5–8/day	1. 14	1. 23	—
9+/day	1. 65	1. 28	—
Pipe only—total	1. 08	1. 06	0. 91
1–4/day	1. 16	0. 91	—
5–19/day	1. 04	1. 10	—
20+/day	—	1. 18	—

*Ratio of annual probability of death for smoking category to that for nonsmokers. Not shown if based on less than 50 deaths observed.

generally greater than might be expected by chance variation alone. Only one category presents both a sizable and significant difference between the two methods of classification. Persons who presently smoke 1 to 9 cigarettes only per day are at appreciably greater risk than the subgroup of current smokers of cigarettes only, whose maximum rate has never exceeded 1 to 9 cigarettes per day. The difference arises, of course, from inclusion among this category of current smokers those who previously smoked a greater amount. The latter individuals might be expected to display higher risks because of the effects of earlier, more intensive exposure to cigarettes. Also, evidence has been presented to show that many persons have cut down on cigarette consumption because they were ill and this group is thus unduly weighted with poor mortality risks (*15*).

Since all results for ex-smokers in this study were tabulated by maximum rate attained, the similarity in mortality ratios for current smokers, whether based on current or maximum amount, simplifies presentation and analysis by permitting the contrast of most of the ex-smoker rates without further qualification with the corresponding current smoker risks classified by current amount.

MORTALITY FROM SPECIFIC CAUSES

Table 6 represents a selection of data from Appendix A to illustrate the range of relationships between type and amount of tobacco use and diseases specified as the underlying cause of death. Generally, the data are quite consistent with those previously reported in this and other studies. For the total group of current cigarette smokers, mortality ratios above 3.0 are observed for cancer of the mouth, pharynx or esophagus, larynx, and lung and bronchus; bronchitis; emphysema without

TABLE 5.—Mortality ratios for current smokers classified by current amount smoked and maximum amount ever smoked, July 1954–December 1962

Smoking category	Current amount smoked	Maximum amount smoked
Current cigarette smokers—total	1. 71	1. 71
1–9/day	1. 31	1. 13
10–20/day	1. 68	1. 59
21–39/day	2. 00	1. 97
39+/day	2. 32	2. 34
Current smokers of cigarettes only—total	1. 84	1. 84
1–9/day	1. 45	1. 16
10–20/day	1. 80	1. 74
21–39/day	2. 05	2. 08
39+/day	2. 32	2. 42
Current smokers of cigarettes and other—total	1. 51	1. 51
1–9/day	1. 17	1. 10
10–20/day	1. 47	1. 38
21–39/day	1. 90	1. 79
39+/day	2. 31	2. 23
Current smokers of cigars only—total	1. 10	1. 10
1–4/day	1. 04	. 97
5–8/day	1. 17	1. 24
8+/day	1. 49	1. 39
Current smokers of pipes only—total	1. 07	1. 07
1–4/day	. 93	. 91
5–19/day	1. 10	1. 05
19+/day	1. 20	1. 25

TABLE 6.—Mortality ratios* for specific underlying causes of death by smoking category, July 1954–December 1962

Cause of death	Current cigarette smokers			Current pipe and/or cigar only smokers	Ex-cigarette smokers†
	Total	10–20/day	21–39/day		
Total cancer (140–205)	2. 08	1. 91	2. 69	1. 25	1. 49
Cancer of mouth, pharynx or esophagus (140–150)	5. 48	4. 01	9. 39	(3. 83)	*(1. 63)*
Cancer of stomach (151)	1. 48	1. 42	1. 57	*1. 21*	*1. 03*
Cancer of intestines (152–153)	1. 17	*1. 14*	1. 31	*1. 20*	1. 27
Cancer of rectum (154)	*0. 90*	*(0. 74)*	*(1. 03)*	*(1. 07)*	*1. 02*
Cancer of pancreas (157)	1. 83	1. 79	2. 15	*(1. 13)*	1. 32
Cancer of larynx (161)	(9. 45)	(8. 33)	(13. 26)	(7. 28)	(7. 22)
Cancer of lung and bronchus (162–163)	10. 88	9. 05	16. 93	1. 67	4. 71
Cancer of prostate (177)	1. 71	1. 80	1. 52	1. 39	1. 63
Cancer of kidney (180)	1. 54	*(1. 57)*	(1. 96)	*(1. 15)*	(1. 65)
Cancer of bladder and other (181)	2. 23	2. 29	3. 15	*(1. 09)*	1. 60
Malignant lymphoma (200, 201, 203)	*1. 15*	*1. 14*	*1. 30*	*(0. 82)*	*1. 10*
Leukemia (204)	1. 49	1. 54	(1. 62)	*(1. 16)*	1. 55
All other cancer	1. 32	1. 24	1. 54	*1. 13*	*1. 07*
Bronchitis (500–502)	3. 78	(4. 34)	(4. 01)	*(0. 48)*	(3. 06)
Emphysema without bronchitis (527. 1)	12. 18	11. 94	16. 27	*(1. 34)*	10. 96
Respiratory tuberculosis (001–008)	(2. 01)	*(1. 98)*	*(2. 21)*	*(0. 39)*	*(1. 24)*
Asthma (241)	(3. 05)	*(2. 15)*	(3. 92)	*(1. 22)*	*(1. 74)*
Influenza and pneumonia (480–493)	1. 59	(1. 66)	(2. 05)	*(0. 79)*	*(0. 93)*

See footnotes at end of table.

TABLE 6.—Mortality ratios* for specific underlying causes of death by smoking category, July 1954–December 1962

Cause of death	Current cigarette smokers: Total	Current cigarette smokers: 10–20/day	Current cigarette smokers: 21–39/day	Current pipe and/or cigar only smokers	Ex-cigarette smokers†
Other respiratory (470–475, 510–526, 527. 0, 527. 2)	1. 42	(*1. 25*)	(*1. 57*)	(*0. 69*)	(*1. 24*)
Total cardiovascular (330–334, 400–468)	1. 62	1. 64	1. 83	1. 05	1. 21
Cerebral vascular lesions (330–334)	1. 40	1. 33	1. 54	*1. 06*	*1. 07*
Chronic rheumatic heart disease (410–416)	*1. 16*	1. 31	(*0. 99*)	(*0. 74*)	*1. 10*
Arteriosclerotic (coronary) heart disease (420)	1. 61	1. 64	1. 82	*1. 05*	1. 21
Nonrheumatic endocarditis, etc. (421–422)	1. 62	1. 68	1. 81	*1. 19*	*1. 22*
Other heart disease (430–434)	1. 96	2. 16	2. 15	(*0. 94*)	1. 31
Hypertension with heart disease (440–443)	1. 47	1. 34	1. 73	*0. 99*	*1. 17*
Hypertension without heart disease (444–447)	1. 33	(*1. 15*)	(1. 78)	(*1. 20*)	(*1. 11*)
General arteriosclerosis (450)	1. 72	1. 84	1. 85	*1. 00*	*1. 16*
Nonsyphilitic aneurysm of aorta (451)	5. 15	5. 58	6. 55	(1. 76)	2. 75
Other circulatory disease (400–402, 452–468)	1. 63	1. 54	1. 97	(*1. 01*)	*1. 21*
Chronic nephritis, etc. (592–594)	*1. 24*	(*1. 19*)	(*1. 49*)	(*1. 18*)	(*1. 26*)
Diabetes mellitus (260)	1. 00	(*1. 07*)	(*0. 96*)	(*1. 25*)	(*0. 58*)
Paralysis agitans (350)	(0. 23)	(0. 26)	(0. 06)	(0. 32)	(0. 56)
Stomach ulcer (540)	4. 08	(4. 14)	(4. 11)	(2. 48)	(3. 40)
Duodenal ulcer (541)	3. 18	(3. 08)	(4. 44)	(*1. 39*)	(1. 83)
Cirrhosis of liver (581)	2. 78	2. 56	2. 98	(1. 82)	(*1. 02*)
Other disease of liver, etc. (580, 582–587)	1. 49	(*1. 39*)	(2. 05)	(*0. 66*)	(*1. 30*)
Violence (800–962, 970–991)	1. 13	*1. 05*	1. 28	*0. 91*	*0. 95*
Ill-defined and unknown‡ (780–79, 5XXX)	1. 62	1. 48	2. 12	*1. 03*	1. 30
All other	1. 60	1. 62	1. 77	1. 21	1. 20
All causes	1. 71	1. 68	2. 00	1. 08	1. 27

*Ratios based on less than 50 deaths are shown in parentheses. Ratios not significantly different from 1.00 at $P<0.01$ are shown in italics.

†Excludes those who stopped because of doctor's orders.

‡Includes cases for which death claim has been paid but death certificates have not yet been received.

bronchitis; asthma; nonsyphilitic aneurysm of the aorta, stomach ulcer, and duodenal ulcer. Data on nonsyphilitic aortic aneurysm had not previously been tabulated as a separate rubric in this study, and its inclusion was suggested by the high risk reported among cigarette smokers in the 25 State American Cancer Society Study (*14*). The present findings agree completely with the risk estimated for the American Cancer Society study cohort. Although the mortality ratio for arteriosclerotic (coronary) heart disease, 1.61, was much smaller than that for any of the above-mentioned diseases, other authors have emphasized the point that coronary disease is responsible for more of the excess deaths among smokers than other causes showing much higher mortality ratios.

The observations to date, 2,430 excess deaths from coronary disease compared to 1,946 for the combination of other causes specified above, support this contention.

The diseases for which current pipe or cigar smokers were at greatly increased risk were cancer of the mouth, pharynx or esophagus, and cancer of the larynx.

The only disease category in table 6 which can be identified as having a mortality ratio significantly below 1.0 was paralysis agitans. The low ratio for this category had been reported by Dorn without comment (*7*, *8*), presumably because the number of deaths observed by him was too small to warrant belaboring or undue emphasis. However, the accumulated data from 8½ years of observation continue to point in the same direction, and the notion that sampling variation could account for the deviation from a true ratio of 1.00 can no longer be entertained seriously. An alternative hypothesis to account for this finding on paralysis agitans would be that it is an artifact arising from the inability of persons with this disease in its advanced stage to continue as smokers, but this supposition is contradicted by the low risk among ex-cigarette smokers. When one calculates the risk for all persons with a history of cigarette smoking, irrespective of whether they were current or discontinued smokers at the onset of the study, we find 40 deaths with paralysis agitans reported as the underlying cause compared to 112.3 expected, or a mortality ratio of 0.36. An artificially low ratio might also result if paralysis agitans were mentioned on the death certificate in combination with other diseases strongly associated with smoking history which tended to be selected as the underlying cause. However, the facts do not support this supposition. Mortality ratios for paralysis agitans, based on its mention as either an underlying *or* contributory cause, were 0.30 for current cigarette smokers and 0.66 for all ex-cigarette smokers, including those who stopped on medical advice. The striking relationship between this disease and smoking, established by 8½ years of observation, raised the question of consistency with other prospective studies. Doll and Hammond were asked about the findings on paralysis agitans for British physicians and the population of the American Cancer Society Study. Both replied (*20*) that their data showed similarly low ratios among those who had ever smoked. The collective data suggest that smoking may in fact be associated with a reduced risk of this disease, and case-control studies might be undertaken to search for related factors and/or host characteristics which differentiate between cases and controls and which might cast light on the observed relationship.

Berkson and others have referred to uniformly higher risks for each cause of death among cigarette smokers as a basis for suspecting this phenomenon is an artifact devoid of etiological meaning (*2*). While we have never subscribed to this interpretation of the data and have viewed the ratios of risks between smokers and nonsmokers for the spectrum of causes considered in previous papers as indicating this association to be cause-specific rather than an across-the-board effect, the result for paralysis agitans represents an interesting outlier for this discussion. For dis-

eases such as cancer of the colon and rectum one could maintain that the difference in risk between smokers and nonsmokers was negligible in comparison to the situation for lung cancer, but paralysis agitans appears to represent a disease for which smokers have a definitely lower risk. This result now makes it even more difficult to defend the position that the association of cigarette smoking with mortality is nonspecific.

Review of Appendix table A indicates that mortality ratios for individual causes determined from counts of underlying causes, or underlying and contributory causes combined, do not yield significantly different results. Exceptions to this rule are emphysema, other respiratory disease, and duodenal ulcer. When contributory causes are included, the mortality ratios for other respiratory disease and duodenal ulcer increase, the mortality ratio for emphysema decreases. One possible interpretation would be that cigarette smoking is more strongly associated with emphysema mortality than with emphysema morbidity. The reverse situation, a stronger association of smoking with morbidity than with mortality, may hold for respiratory disease and duodenal ulcer.

CONSTITUTIONAL HYPOTHESIS

Many studies, in addition to this one (*3–6, 9, 10, 13, 14, 22*), have shown cigarette smokers to have higher mortality rates than nonsmokers. The nature of these observations is such that they do not prove that smoking causes disease. The possibilities are: Cigarette smoking is a cause of disease (causal hypothesis); smoking and disease have common causes (constitutional hypothesis); or disease causes smoking. An evaluation of these alternatives with respect to lung cancer (*4*) pointed out that an unequivocal answer would call for long-term controlled experiments on human subjects, but that the weight of observational and experimental evidence in hand favored the causal hypothesis. The constitutional hypothesis has led various workers to consider such host characteristics as personality type (*11, 18*) and body build (*21*). While the present study does not include measurements on these factors, it can provide some evidence as to whether constitutional or genetically determined factors can account for the observed differentials in mortality risks.

The arguments underlying the constitutional hypothesis are that persons who smoke are not the same kind of people as those who do not; that those who begin smoking at an early age are different from those who begin at an older age; that those who discontinue are not the same kind of people as those who continue smoking, etc. The data available to test this involve the comparisons of mortality risk among ex-cigarette smokers according to length of time since discontinuance. The statistic "number of years since discontinuance" was calculated from information on age at time cigarette smoking was stopped in 5-year class intervals and attained age. Attained age in single years was computed for each surviving

individual annually and "number of years since discontinuance" was determined by subtraction of the midpoint of the 5-year age class for age at discontinuance from attained age. Because one age was exact while the other was an estimate, the value derived by the computer is an approximation and could deviate by as much as ±2.5 years from the correct value. If any gradient of risk exists with respect to duration since discontinuance, this approximation would tend to diminish our ability to detect it.

If the data show no difference in risk with respect to duration since smoking was stopped, this, by itself, would not discriminate between the constitutional hypothesis and a causal hypothesis which stipulated that the risk associated with cigarette smoking was an immediate or short-term effect which disappeared shortly after withdrawal from the habit. If the data show that those who have stopped for a long time have lower rates than recent ex-smokers, the constitutional hypothesis would require elaboration and modification (particularly as related to genetically determined characteristics) to accommodate these findings.

Two exclusions from the available data for ex-cigarette smokers will serve to sharpen the comparison intended. Both of these relate to the well-established fact that death rates in the first few years after discontinuance are high because illness is one of the important motivations for giving up smoking (*14*, *15*). The effect of illness as a reason for discontinuance on the rates for ex-smokers can be reduced by exclusion from the tabulation of all persons who discontinued because of doctor's orders. The other method would be to limit the data to those who had stopped for 5 years or more and determine if a risk gradient is evident for the intervals 5–9, 10–14, and 15 years or more since discontinuance. Both devices were incorporated into the analysis presented in table 7. To detect changes in risk over time, that are in fact associated with elapsed calendar time rather than arising from indirect association with other variables, it is important to hold constant as many other significant variables as possible. To this end, the comparisons among 5–9, 10–14, and 15 or more years since discontinuance in table 7 have been made specific for:

(*a*) Age began cigarette smoking: <15, 15 to 19, 20 to 24, 25+
(*b*) Age at observation: 55 to 64, 65 to 74 (insufficient data at other ages)
(*c*) Maximum number of cigarettes per day: 10 to 20, 21 to 39, 40+
(*d*) Cause of death: all causes, coronary heart disease, lung cancer.

If the annual probability of death in any cell defined by the above variables was based on less than 50 person-years of observation at any single year of age, the data for that cell are not shown. A pattern of regular decrease in risk with increasing time since discontinuance is clearly evident. Those few rates not fitting this regular pattern have been *italicized* for convenient identification. A measure of how often such a configuration of rates would result from the operation of chance alone can be determined by computation of how many different orderings of

TABLE 7.—Annual probability of death $\times 10^5$ * for ex-cigarette smokers by number of years† since discontinuance (excludes persons who stopped because of doctor's orders) July 1954–December 1962

Maximum amount smoked	Present age	Age began cigarette smoking	All causes			Coronary heart disease‡			Lung cancer‡		
			Years since stopped			Years since stopped			Years since stopped		
			5–9	10–14	15+	5–9	10–14	15+	5–9	10–14	15+
10–20/day	55–64	15–19	1566	*1033*	1224	803	508	469	137	*11*	40
10–20/day	55–64	20–24	1280	1215	1055	661	*705*	426	66	*0*	10
10–20/day	65–74	15–19	—	3050	2734	—	1364	1097	—	196	54
10–20/day	65–74	20–24	—	3663	2380	—	1834	973	—	151	92
10–20/day	65–74	25+	—	3287	2886	—	1496	1217	—	91	56
21–39/day	55–64	15–19	2090	1883	1224	1038	*605*	630	161	*221*	10
21–39/day	65–74	15–19	—	4232	2461	—	1842	1078	—	350	148
21–39/day	65–74	20–24	—	3662	3378	—	1334	971	—	252	78

*Not shown if less than 50 person-years of observation at any single year of age in the 10-year interval.
† With the passage of each calendar year since the receipt of the smoking questionnaire, the number of years since smoking was stopped was increased by one.
‡ Underlying cause.

the given rates for each disease could be obtained. There are 6,912 such arrangements possible, of which only 1 would be in perfect order of decreasing risk with increasing time, 12 would contain a single inversion (*1*) or less, 70 would contain two inversions or less, and 265 would contain 3 inversions or less. In table 7 the data show 1 inversion for all causes of death, 2 inversions for coronary heart disease, and 3 inversions for lung cancer. The probability of this or a smaller number of inversions arising just by chance is 0.002, 0.010, and 0.038, respectively. These data do not support either the constitutional hypothesis or the hypothesis that the coronary disease risk for ex-smokers reverts to the nonsmoker level within a short time after discontinuance (*9*).

BIAS OF SELECTION

The Advisory Committee to the Surgeon General (*22*) discussed nonresponse bias in detail, making principal reference to this study. They concluded "under assumptions that are rather extreme, though consistent with the available data about nonrespondents" that "reported mortality ratios lying between one and two might overestimate by as much as 0.3, a mortality ratio of 5.0 might overestimate by 1.0, and one of 10.0 might overestimate by 3.0." The Committee's estimate of the possible overestimation of true mortality ratios was a one-sided limit and not intended as an indicator of how much the data for respondents did deviate from those for the total study population.

The Committee's calculation required assumptions with respect to 1) the percentage distribution of cigarette only smokers and nonsmokers among nonrespondents, 2) the relationship of death rates for the combined groups of cigarette smokers plus nonsmokers in the respondent and total populations, and 3) the ratio of nonrespondent to respondent death rates for cigarette smokers. We will repeat their approach to the question of response bias with a change at one point to substitute observed data for extreme assumptions. For the first 3 years of the study, the observed (not assumed) annual probabilities of death from all causes for persons aged 55 to 64 are shown in table 8a. The small figures in the upper left corner of each cell indicate the proportionate contribution of each category to the total population, based on the distribution of person-years of observation for the interval July 1954 to June 1957.

Instead of contrasting "Never smoked" with "Cigarette only" as the Committee calculation did, table 8a replaces "Cigarette only" with "All other." This permits the use of *observed* death rates for the total nonrespondent population. The mortality ratio for this particular contrast is simply the observed age-specific rate for the "All other" category divided by the corresponding rate for the "Never smoked" (1,569/1,102 = 1.42). For computation of a mortality ratio for the total population, some estimates are required concerning the nonrespondent rates by smoking category. We have used the July 1957 to December 1960 mortality

experience for attained ages 55 to 64 of the 1957 respondents as an approximation of the rates for the total nonrespondent population of like age in the earlier time period and inserted the additional entries shown in table 8b. The segregation of the marginal entry of 0.314 representing the proportion of the population who were originally nonrespondents into components of 0.071 for "Never smoked" and 0.243 for "All other" is based on the person-years of observation allocated to these categories in the July 1957 to December 1960 experience for the 1957 respondents.

TABLE 8.—Annual probabilities of death × 10^5 derivation of data for total population, July 1954–June 1957, age 55–64

	Never smoked	All other	Total
a			
Nonrespondent	—	—	.314 1831
Respondent	.174 1102	.512 1569	.686 1451
Total	—	—	1.000 1569
b			
Nonrespondent	.071 1235	.243 1919	.314 1831
Respondent	.174 1102	.512 1569	.686 1451
Total	—	—	1.000 1569
c			
Nonrespondent	.071 1282	.243 1992	.314 1831
Respondent	.174 1102	.512 1569	.686 1451
Total	.245 1154	.755 1705	1.000 1569

Because the rates for nonrespondents by smoking category were obtained from an independent source, they could not be expected to be numerically consistent with the rate for total nonrespondents. The rate for the latter is based on direct observation, and the appropriate correction would be to force the rates for nonrespondents by smoking category to agree with that for total nonrespondents. The estimated rates for nonrespondents by smoking category collapse into a total rate less than the observed value by a factor of 1.038 and the two nonrespondent rates were adjusted upward by this amount. Carrying out this adjustment completes table 8c, which yields an estimated mortality ratio for the total population in the 55 to 64 age group of 1.48 (1705/1154), which is slightly *larger* than the 1.42 observed for the respondent population alone.

The intent in presentation of this alternate calculation is not to dispute the Committee's attempt to place an upper bound on overstatements

of excess mortality risks among smokers, but to note that observations made during the study suggest the possibility that respondent data may in fact underestimate the risk associated with smoking. One of the differences between table 8 and the Committee's calculation is that table 8 utilizes respondent data for the July 1954 to June 1957 interval, whereas the latter considered respondent data for the period after July 1957 to relate the data for respondents and nonrespondents to the same calendar period. In a comparison of the experience of the 1954 and 1957 respondents, the choice is between keeping calendar time constant or equating the mortality in the years immediately after the return of the questionnaire. Because the situation is not static and changes are taking place over time, the two approaches will lead to different results. For example, basing table 8 on respondent data for the July 1957 to December 1960 calendar period results in an observed mortality ratio of 1.59 instead of the 1.42 observed for the July 1954 to June 1957 period. Completing the remainder of the calculations in the manner already described would lead to an estimated mortality ratio of 1.59 for the total population, unchanged from the value observed for respondents alone. Thus, depending on the time period taken as a base, the comparative mortality ratios are 1.42 for respondents and 1.48 for the total population, or 1.59 for both respondents and total population.

Whatever bias of selection exists, it should be greatest in the initial period and less in subsequent years, in accord with the typical experience in life insurance underwriting where the effects of medical selection are felt most strongly in the early years following issuance of a policy (*17*). Under these conditions one would expect the respondent and total insured population death rates to converge over time. The data in table 9 show that convergence has in fact occurred.

TABLE 9.—Annual probability of death $\times 10^5$; comparison of 1954 respondent and total insured populations in successive calendar periods, July 1954–December 1962

Period	45–84*		
	Total	1954 Respondents	Ratio total/1954 respondents
July 1954–June 1957	2, 390	2, 190	1. 091
July 1957–Dec. 1960	2, 316	2, 150	1. 077
Jan. 1961–Dec. 1962	2, 180	2, 074	1. 051

*Ten-year averages were combined according to the distribution of total person-years of observation in the study.

The indicated decline of over 8 percent in the age-adjusted risk of death for the total population age 45 to 84 from 1954–57 to 1961–62 must be an overstatement. One artifact affecting the data is that several years must elapse after year x before the delayed receipt of certificates for deaths occurring in year x diminishes to a negligible number. Another contrib-

uting factor would be the increasing proportion of policies terminated for reasons other than death, since the chance of prompt notification of death is not as great for these individuals as for those holding active policies.

The effect of the delayed receipt of death information is such as to understate the probability of death for the most recent period by about 4 percent. Without a special investigation going beyond Veterans Administration sources of information, it is difficult to evaluate the second factor, but it seems unlikely to be responsible for more than a 1 percent decrease. The true decrease from 1954–57 to 1961–62 is thus estimated to be about 3 percent, with the remaining 5 percent discounted as assignable to artifacts. The results for the two earlier periods are no longer seriously affected by these considerations.

The mortality ratios calculated for the separate calendar time periods are presented for detailed smoking classes in Appendix C, and a few major categories are summarized in table 10. The ratios for each period and respondent group were calculated independently so that they can be compared as if they came from separate studies.

TABLE 10.—Mortality ratios* by smoking category, respondent group and time period, July 1954—December 1962

Smoking category	1954 Respondents			1957 Respondents	
	7/54–6/57	7/57–12/60	1/61–12/62	7/57–12/60	1/61–12/62
Current cigarette smokers	1. 59	1. 76	1. 86	1. 53	1. 81
Current cigar only smokers	. 95	1. 17	1. 20	1. 02	1. 07
Current pipe only smokers	1. 08	1. 11	1. 08	. 79	1. 13
Ex-cigarette smokers (stopped on doctor's orders)	2. 08	1. 85	1. 85	1. 89	2. 10
Ex-cigarette smokers (stopped for other reasons)	1. 22	1. 26	1. 37	1. 18	1. 35
Ex-cigar only smokers (stopped for other reasons)	1. 38	1. 16	1. 35	1. 14	—
Ex-pipe only smokers (stopped for other reasons)	1. 24	1. 23	1. 03	—	—

*Not shown if based on less than 50 deaths.

Among the 1954 respondents who were current smokers, there seems to be a definite upward gradient in the mortality ratio over time for cigarette or cigar only smokers. The data for the 1957 respondents reinforce this upward trend for cigarette smokers. Apparently, the nature of the selective bias operating among respondents was such as to understate the risk in the initial period associated with these two categories. The mortality ratio for current pipe smokers remains fairly level over the time periods shown and one might infer that selective bias had little effect on this group. Among ex-smokers who stopped for reasons other than doctor's orders there is an indication of upward trend in mortality ratio for ex-cigarette smokers but not for ex-cigar only or ex-pipe only smokers. Thus, the mortality ratios for both current and ex-cigarette smokers may have been

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understated in the first returns from this study with little or no evidence that this effect also occurred in other smoking classes.

Of course, the mortality ratios are composite figures dependent on data both for a particular smoking category and the never smoked group. To identify the factors responsible for the upward trend in mortality ratios for current cigarette smokers, it is necessary to review the risk of death for each category over time. This has been done in table 11 in terms of mortality ratios for each time period relating the observed deaths in that time period to expected deaths based on the force of mortality among all nonsmokers over the entire 8½-year observation period.

Table 11.—Mortality ratios* by calendar time period, cigarette smokers and never or occasional only smokers by respondent group, July 1954–December 1962

Period	Mortality ratios	
	Never or occasional only smokers	Current cigarette smokers
1954 Respondents:		
July 1954–June 1957	1.07	1.70
July 1957–December 1960	0.99	1.72
January 1961–December 1962	0.86	1.61
1957 Respondents:		
July 1957–December 1960	1.24	1.90
January 1961–December 1962	1.01	1.80

*Observed deaths in separate time periods as a ratio to expected deaths based on force of mortality computed for nonsmokers from data for the entire 8½ years.

The mortality ratios in table 11 are different from those in table 10 in an important respect. In order to reveal whether a change in mortality ratio over time is due to a change in mortality experience for smokers, nonsmokers, or both, all the ratios in table 11 have been calculated in terms of the same expected mortality. Because of this common expectation, any changes observed in table 11 mortality ratios over time for a specified smoking class are attributable to changes in the observed mortality experience for that particular category. From inspection of table 11 it is clear that the upward trend in mortality ratio for current cigarette smokers shown in table 10 is principally due to a decrease over time in mortality risk among the nonsmokers. The mortality ratios for current cigarette smokers calculated on the basis of the same expectation of deaths per unit exposed to risk are essentially constant over the three time periods. The reduced ratios for current cigarette smokers for the 1961–62 period simply reflect the artifact of delayed receipt of death certificates for the most recent period. In contrast, the mortality ratios for nonsmokers show a definite downward trend with time.

In an earlier section of this paper, reference was made to two kinds of follow-up. One is based on a notification from the Veterans Administration when an active policyholder dies and a claim is paid. The

second depends on a periodic query to the Veterans Administration requesting the mortality status of persons who have terminated their insurance for reasons other than death. The interpretation of the foregoing data concerning the downward trend in probability of death for nonsmokers would need to be modified if nonsmokers terminated policies proportionately more often than cigarette smokers and were thus subject to a less complete mortality follow-up.

The straightforward way to investigate this would have been to determine for each respondent group, by smoking category, the proportion of persons alive or dead who had terminated their insurance. Unfortunately, the record-keeping system is such that notification of death "erases" the terminated status code and the information is available only for those still alive (table 12).

Table 12.—Percent of persons terminating policies for reasons other than death, July 1954–December 1962

	Percent terminated		
	Never or occasional only smokers	Current cigarette smokers	Total
Among 1954 respondents alive as of 12/31/62	14. 7	15. 5	—
Among 1957 respondents alive as of 12/31/62	16. 1	16. 5	—
Among nonrespondents alive as of 12/31/62	—	—	16. 6

Among those still alive, the proportion who terminated their policies is slightly less among nonsmokers than among current smokers. This trivial difference would argue against the likelihood of the downward trend in probability of death for nonsmokers being due to an excess rate of policy terminations. Irrespective of the termination status of persons who have died, it was a possible accumulation of living terminated cases among nonsmokers that might have artificially produced a drop in observed mortality for this group. The data show that this did not happen.

The possibility that some fraction of the death reports was erroneously omitted from the computer tabulations is unlikely in view of the agreement among control checks on certificates processed, cards punched, and computer table totals. In addition, all procedures for processing death certificates are independent of smoking status so that a shortage due to error would be expected to affect all smoking categories and not just a particular one.

If separate calendar time sequences are used to analyze the effects of bias selection, there is no way to separate the wearing-off of special selection factors from independent calendar time trends. Thus, the data suggest that current cigarette smoker mortality ratios were either understated in the early years of this study or else some part of the increase in

mortality ratios observed in later years is due to a real downward secular trend in nonsmoker rates not accompanied by similar decreases for smokers. Additional data will be required to resolve this question.

SUMMARY

In an 8½-year follow-up of 293,658 persons holding U.S. Government Life Insurance policies, the increased mortality risk associated with cigarette smoking was found to be higher in the more recent calendar time period than in the initial years of the study. Over-all findings were similar to those reported after 2½ years of follow-up. For the entire period, mortality ratios of current cigarette smokers compared with those who have never smoked are 1.7 for death from all causes, 10.9 for lung cancer, 12.2 for emphysema without bronchitis, and 1.6 for coronary heart disease. Paralysis agitans was the only cause of death associated with significantly lower mortality for smokers than for nonsmokers.

For all categories of current smokers, risk was related to amount smoked. The risk for cigarette smokers was much greater than that for pipe or cigar smokers. Current smokers of cigarettes, cigars, or pipes experienced a mortality risk significantly greater than that for nonsmokers if they smoked more than four pipes or four cigars daily or more than an occasional cigarette.

There was a positive relationship between duration of cigarette smoking and mortality risk from all causes of death for at least some classifications of smokers.

Comparison of age-specific probabilities of death for ex-cigarette smokers revealed a downward trend in risk as duration of time discontinued increased, when other variables—age began smoking, amount smoked, and current age—were controlled. The data can be regarded as evidence against the constitutional hypothesis.

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APPENDIX TABLES A, B, C, AND D, AND APPENDIX E

Appendix table A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962

	NEVER SMOKED OR OCCASIONAL ONLY					
	Total 35–84	35–44	45–54	55–64	65–74	75–84
Person-years of observation:	443,856	35,164	15,134	213,858	171,211	8,489

Cause of death (underlying cause unless otherwise specified, International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10⁵*					Number of deaths					
		35–44	45–54	55–64	65–74	75–84	Total 35–84	35–44	45–54	55–64	65–74	75–84
All causes	1.00	127	264	1,056	2,411	6,214	6,932	47	38	2,617	3,728	502
Cancer, all sites (140–205)	1.00	22	58	200	405	1,016	1,231	8	8	488	638	89
Cancer of buccal cavity (140–144)	1.00	—	—	2	4	—	11	—	—	5	6	—
Cancer of pharynx (145–148)	1.00	—	—	—	1	7	4	—	—	1	2	1
Cancer of esophagus (150)	1.00	—	—	1	3	45	11	—	—	4	4	3
Cancer of stomach (151)	1.00	2	10	13	28	87	96	1	1	39	46	9
Cancer of intestines (152–153)	1.00	—	—	33	61	107	200	—	—	94	95	11
Cancer of rectum (154)	1.00	—	—	28	29	29	96	—	—	48	46	2
Cancer of pancreas (157)	1.00	—	—	13	29	109	88	—	—	37	43	8
Cancer of larynx (161)	1.00	—	—	1	—	13	3	—	—	2	—	1
Cancer of lung and bronchus (162–163)	1.00	—	—	10	30	46	78	—	—	25	49	4
Cancer of prostate (177)	1.00	—	—	7	51	209	117	—	—	23	76	18
Cancer of kidney (180)	1.00	—	—	8	14	7	39	—	—	15	23	1
Cancer of bladder and other (181)	1.00	—	—	8	22	89	52	—	—	15	29	8
Malignant lymphoma (200, 201, 203)	1.00	3	5	23	31	110	122	1	1	54	56	10
Leukemia (204)	1.00	4	—	14	25	45	75	1	—	35	35	4
All other sites (155–156, 158–160, 164–165, 170–176, 178–179, 190–199, 202, 205)	1.00	13	44	40	78	116	239	5	6	91	128	9
Bronchitis and/or emphysema	1.00	—	—	2	10	54	31	—	—	6	21	4
Bronchitis (500–502)	1.00	—	—	1	5	10	13	—	—	2	10	1
Underlying or contributory	1.00	—	5	1	16	23	34	—	1	4	27	2
Emphysema without bronchitis (527.1)	1.00	—	—	1	5	45	18	—	—	4	11	3
Underlying or contributory	1.00	—	—	5	28	119	71	—	—	14	49	8
Respiratory tuberculosis (001–008)	1.00	—	—	1	8	13	16	—	—	3	12	1
Underlying or contributory	1.00	—	—	3	15	27	37	—	—	8	26	3

Asthma (241)	1.00	—	—	3	2	—	9	—	—	6	3	—
Underlying or contributory	1.00	—	—	9	11	28	39	—	—	15	22	2
Influenza and pneumonia (480–493)	1.00	—	—	3	19	56	41	—	—	11	25	5
Underlying or contributory	1.00	5	14	48	220	667	483	2	2	125	303	51
Other respiratory disease (470–475, 510–526, 527.0, 527.2)	1.00	—	6	5	12	109	41	—	1	14	19	7
Underlying or contributory	1.00	3	20	13	50	224	141	1	3	41	81	15
Total cardiovascular disease (330–334, 400–468)	1.00	31	113	683	1, 614	4, 258	4, 525	11	17	1, 697	2, 470	330
Cerebral vascular lesions (330–334)	1.00	10	11	59	280	834	614	4	1	162	385	62
Underlying or contributory	1.00	10	27	101	424	1, 244	960	4	3	268	590	95
Chronic rheumatic heart disease (410–416)	1.00	—	—	20	25	26	90	—	—	48	40	2
Underlying or contributory	1.00	—	—	30	48	35	151	—	—	73	75	3
Arteriosclerotic (coronary) heart disease (420)	1.00	18	50	501	1, 015	2, 216	2, 997	6	9	1, 218	1, 587	177
Underlying or contributory	1.00	18	54	557	1, 203	2, 937	3, 489	6	10	1, 366	1, 875	232
Nonrheumatic endocarditis, etc. (421–422)	1.00	—	5	15	49	175	131	—	1	37	80	13
Underlying or contributory	1.00	6	5	36	100	441	277	2	1	88	154	32
Other heart disease (430–434)	1.00	—	10	10	36	139	89	—	1	27	52	9
Underlying or contributory	1.00	—	30	62	156	557	464	—	4	169	249	42
Hypertension with heart disease (440–443)	1.00	—	22	39	80	131	226	—	3	95	117	11
Underlying or contributory	1.00	5	26	110	208	495	614	2	4	255	317	36
Hypertension without heart disease (444–447)	1.00	—	—	12	13	60	49	—	—	23	22	4
Underlying or contributory	1.00	—	—	30	47	109	141	—	—	63	71	7
General arteriosclerosis (450)	1.00	—	11	13	74	591	195	—	1	45	108	41
Underlying or contributory	1.00	2	16	61	279	1, 554	673	1	2	170	387	113
Nonsyphilitic aneurysm of aorta (451)	1.00	—	4	6	25	47	58	—	1	17	37	3
Other circulatory disease (400–402, 452–468)	1.00	2	—	9	25	109	76	1	—	25	42	8
Chronic nephritis, etc. (592–594)	1.00	2	—	6	9	48	32	1	—	13	14	4
Underlying or contributory	1.00	2	—	18	21	48	72	1	—	33	34	4
Diabetes mellitus (260)	1.00	—	—	5	13	96	42	—	—	16	19	7
Underlying or contributory	1.00	2	9	42	134	422	365	1	2	126	204	32
Paralysis agitans (350)	1.00	—	—	6	23	74	58	—	—	15	36	7
Underlying or contributory	1.00	—	6	9	55	148	122	—	1	26	82	13
Stomach ulcer (540)	1.00	—	—	2	5	—	12	—	—	5	7	—
Underlying or contributory	1.00	—	—	6	11	13	32	—	—	14	17	1
Duodenal ulcer (541)	1.00	—	—	4	10	37	25	—	—	10	13	2
Underlying or contributory	1.00	—	—	8	16	77	42	—	—	15	23	4
Cirrhosis of liver (581)	1.00	—	9	15	16	53	56	—	1	23	28	4
Other diseases of liver, etc. (580, 582–587)	1.00	—	—	5	18	12	35	—	—	11	23	1
Violence (800–962, 970–991)	1.00	60	58	70	83	83	332	22	8	161	133	8
Ill-defined and unknown (780–795, XXX)†	1.00	2	—	19	93	153	204	1	—	60	130	13
All other	1.00	10	21	30	89	253	242	4	3	78	137	20

See footnotes at end of Appendix table A.

APPENDIX TABLE A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

	CURRENT SMOKERS—TOTAL					
	Total 35–84	35–44	45–54	55–64	65–74	75–84
Person-years of observation:	897,712	125,589	40,603	428,347	290,104	13,068

Cause of death (underlying cause unless otherwise specified International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10^5*					Number of deaths					
		35–44	45–54	55–64	65–74	75–84	Total 35–84	35–44	45–54	55–64	65–74	75–84
All causes	1. 54	228	683	1, 669	3, 608	7, 327	19, 234	296	271	8, 185	9, 572	910
Cancer, all sites (140–205)	1. 86	38	140	368	776	1, 419	4, 152	46	52	1, 832	2, 044	178
Cancer of buccal cavity (140–144)	3. 79	—	4	6	12	13	76	—	1	35	37	3
Cancer of pharnyx (145–148)	7. 75	—	—	6	11	25	54	—	—	23	28	3
Cancer of esophagus (150)	5. 32	1	—	8	17	87	100	1	—	45	44	10
Cancer of stomach (151)	1. 41	2	10	22	44	93	246	3	4	107	121	11
Cancer of intestines (152–153)	1. 18	3	13	36	84	160	426	4	4	183	214	21
Cancer of rectum (154)	. 95	1	12	16	32	21	168	1	4	79	81	3
Cancer of pancreas (157)	1. 64	5	12	24	46	64	256	6	5	112	125	8
Cancer of larynx (161)	8. 88	—	—	5	12	14	51	—	—	21	28	2
Cancer of lung and bronchus (162–163)	8. 44	5	37	113	211	252	1, 178	6	15	550	572	35
Cancer of prostate (177)	1. 62	—	4	17	77	278	323	—	1	104	187	31
Cancer of kidney (180)	1. 44	—	3	10	17	59	102	—	1	50	43	8
Cancer of bladder and other (181)	1. 90	—	7	13	37	37	172	—	2	72	92	6
Malignant lymphoma (200, 201, 203)	1. 07	6	9	21	44	48	240	6	3	101	123	7
Leukemia (204)	1. 41	5	4	21	34	49	194	6	1	90	90	7
All other sites (155–156, 158–160, 164–165, 170–176, 178–179, 190–199, 202, 205)	1. 27	11	26	51	101	230	566	13	11	260	259	23
Bronchitis and/or emphysema	6. 49	1	4	18	84	156	348	1	1	108	218	20
Bronchitis (500–502)	2. 86	1	—	3	16	30	64	1	—	15	44	4
Underlying or contributory	3. 48	2	2	14	49	129	206	2	1	65	122	16
Emphysema without bronchitis (527. 1)	9. 09	—	4	15	68	126	284	—	1	93	174	16
Underlying or contributory	6. 50	5	25	43	200	403	798	6	9	240	491	52
Respiratory tuberculosis (001–008)	1. 55	—	—	4	7	11	43	—	—	20	22	1
Underlying or contributory	1. 99	—	9	13	20	39	128	—	4	61	58	5

Asthma (241)	2. 62	1	8	4	8	6	45	1	2	21	20	1
Underlying or contributory	2. 51	3	12	16	35	63	179	3	3	75	89	9
Influenza and pneumonia (480–493)	1. 36	1	6	4	22	115	95	1	2	26	53	13
Underlying or contributory	1. 61	11	24	94	298	923	1, 350	14	9	484	734	109
Other respiratory disease (470–475, 510–526, 527.0, 527.2)	1. 22	1	8	6	17	51	88	1	2	35	44	6
Underlying or contributory	1. 81	5	28	34	97	167	452	7	10	168	247	20
Total cardiovascular disease (330–334, 400–468)	1. 47	99	362	1, 052	2, 262	4, 802	11, 867	132	146	5, 077	5, 931	581
Cerebral vascular lesions (330–334)	1. 30	9	18	105	299	1, 015	1, 394	13	7	520	736	118
Underlying or contributory	1. 33	14	33	166	485	1, 552	2, 234	19	12	837	1, 187	179
Chronic rheumatic heart disease (410–416)	1. 06	1	7	20	30	67	175	1	4	84	79	7
Underlying or contributory	1. 11	1	8	30	57	127	306	1	5	137	149	14
Arteriosclerotic (coronary) heart disease (420)	1. 46	73	300	755	1, 419	2, 413	7, 893	97	117	3, 592	3, 793	294
Underlying or contributory	1. 49	79	320	863	1, 734	3, 185	9, 327	104	126	4, 129	4, 584	384
Nonrheumatic endocarditis, etc. (421–422)	1. 50	1	7	23	85	244	348	2	3	108	209	26
Underlying or contributory	1. 62	3	17	62	174	529	798	4	6	292	437	59
Other heart disease (430–434)	1. 68	1	5	22	54	135	262	2	3	102	140	15
Underlying or contributory	1. 81	10	34	118	318	643	1, 497	13	14	592	806	72
Hypertension with heart disease (440–443)	1. 35	4	11	48	103	252	550	5	6	246	263	30
Underlying or contributory	1. 36	6	23	136	274	583	1, 509	8	12	678	740	71
Hypertension without heart disease (444–447)	1. 30	1	3	10	25	53	117	1	1	43	65	7
Underlying or contributory	1. 50	3	7	37	70	213	385	3	3	169	182	28
General arteriosclerosis (450)	1. 50	2	8	27	130	510	497	2	3	136	299	57
Underlying or contributory	1. 44	6	17	111	396	1, 365	1, 667	8	6	551	945	157
Nonsyphilitic aneurysm of aorta (451)	4. 23	1	2	27	100	147	433	1	1	155	257	19
Other circulatory disease (400–402, 452–468)	1. 46	6	2	17	33	59	198	8	1	91	90	8
Chronic nephritis, etc. (592–594)	1. 23	—	3	8	10	51	73	—	2	39	27	5
Underlying or contributory	1. 20	1	3	12	33	65	160	1	2	68	82	7
Diabetes mellitus (260)	1. 07	1	—	6	16	24	79	1	—	35	40	3
Underlying or contributory	1. 18	8	11	56	155	291	758	9	4	293	416	36
Paralysis agitans (350)	. 26	—	—	1	8	15	26	—	—	5	18	3
Underlying or contributory	. 32	—	—	2	19	67	68	—	—	15	43	10
Stomach ulcer (540)	3. 66	1	—	7	13	40	78	1	—	37	34	6
Underlying or contributory	3. 10	4	—	18	30	76	179	4	—	84	79	12
Duodenal ulcer (541)	2. 69	1	5	9	27	49	119	1	3	46	62	7
Underlying or contributory	3. 75	2	11	22	61	94	280	2	6	108	149	15
Cirrhosis of liver (581)	2. 53	3	7	27	46	43	263	4	4	115	134	6
Other diseases of liver, etc. (580, 582-587)	1. 26	1	6	9	12	24	78	1	3	35	36	3
Violence (800–962, 970–991)	1. 08	60	80	73	84	205	710	79	33	332	242	24
Ill-defined and unknown (780–795, XXX)†	1. 46	12	32	30	120	212	519	15	13	168	299	24
All other	1. 50	10	24	51	135	265	651	12	8	254	348	29

See footnotes at end of Appendix table A.

Appendix table A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

	CURRENT CIGARETTE SMOKERS—TOTAL					
	Total 35–84	35–44	45–54	55–64	65–74	75–84
Person-years of observation:	701, 768	116,320	35,570	334,175	207,895	7,808

Cause of death (underlying cause unless otherwise specified, International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10^5*					Number of deaths					
		35–44	45–54	55–64	65–74	75–84	Total 35–84	35–44	45–54	55–64	65–74	75–84
All causes	1. 71	232	728	1, 819	4, 032	8, 471	15, 644	279	250	6, 928	7, 569	618
Cancer, all sites (140–205)	2. 08	40	145	406	881	1, 642	3, 422	45	47	1, 575	1, 635	120
Cancer of buccal cavity (140–144)	3. 75	—	—	7	11	14	56	—	—	29	25	2
Cancer of pharynx (145–148)	9. 60	—	—	7	14	43	48	—	—	20	25	3
Cancer of esophagus (150)	5. 87	1	—	9	16	134	77	1	—	37	31	8
Cancer of stomach (151)	1. 48	2	12	23	45	87	191	3	4	90	89	5
Cancer of intestines (152–153)	1. 17	3	11	36	91	152	313	4	3	139	154	13
Cancer of rectum (154)	. 90	1	13	16	34	14	120	1	4	56	58	1
Cancer of pancreas (157)	1. 83	5	9	25	49	94	208	6	4	95	97	6
Cancer of larynx (161)	9. 45	—	—	5	11	23	40	—	—	17	21	2
Cancer of lung and bronchus (162–163)	10. 88	5	42	138	281	406	1, 116	6	14	528	537	31
Cancer of prostate (177)	1. 71	—	4	18	76	293	242	—	1	88	135	18
Cancer of kidney (180)	1. 54	—	3	11	18	66	81	—	1	41	33	6
Cancer of bladder and other (181)	2. 23	—	8	13	44	61	144	—	2	58	78	6
Malignant lymphoma (200, 201, 203)	1. 15	6	10	25	46	34	193	6	3	91	90	3
Leukemia (204)	1. 49	5	4	21	38	86	153	5	1	72	68	7
All other sites (155–156, 158–160, 164–165, 170–176 178–179, 190–199, 202, 205)	1. 32	12	28	53	109	147	440	13	10	214	194	9
Bronchitis and/or emphysema	8. 65	—	5	23	112	259	333	—	1	106	207	19
Bronchitis (500–502)	3. 78	—	—	4	21	50	61	—	—	15	42	4
Underlying or contributory	4. 36	1	3	16	63	176	187	1	1	59	112	14
Emphysema without bronchitis (527.1)	12. 18	—	5	19	91	209	272	—	1	91	165	15
Underlying or contributory	8. 57	5	27	53	270	674	752	6	8	228	461	49
Respiratory tuberculosis (001–008)	2. 01	—	—	5	9	21	40	—	—	19	20	1
Underlying or contributory	2. 43	—	11	15	26	44	113	—	4	55	51	3

Asthma (241)	3. 05	1	9	5	9	10	40	1	2	19	17	1
Underlying or contributory	3. 00	2	14	19	47	65	159	2	3	67	81	6
Influenza and pneumonia (480–493)	1. 59	1	5	5	26	167	79	1	1	22	45	10
Underlying or contributory	1. 90	10	21	106	353	1, 261	1, 141	12	7	427	613	82
Other respiratory disease (470–475, 510–526, 527.0, 527.2)	1. 42	1	9	7	19	69	74	1	2	30	36	5
Underlying or contributory	2. 10	5	32	35	113	224	380	7	10	141	206	16
Total cardiovascular disease (330–334, 400–468)	1. 62	102	394	1, 149	2, 502	5, 331	9, 580	126	137	4, 295	4, 641	381
Cerebral vascular lesions (330–334)	1. 40	8	21	108	326	1, 160	1, 073	10	7	417	562	77
Underlying or contributory	1. 44	13	37	175	535	1, 727	1, 740	16	12	680	916	116
Chronic rheumatic heart disease (410–416)	1. 16	1	8	24	31	78	144	1	4	75	59	5
Underlying or contributory	1. 21	1	10	35	60	152	247	1	5	123	108	10
Arteriosclerotic (coronary) heart disease (420)	1. 61	76	326	833	1, 559	2, 556	6, 395	94	110	3, 064	2, 943	184
Underlying or contributory	1. 65	82	349	951	1, 925	3, 436	7, 580	101	119	3, 522	3, 593	245
Nonrheumatic endocarditis, etc. (421–422)	1. 62	2	8	24	93	229	272	2	3	90	164	13
Underlying or contributory	1. 80	3	15	66	197	582	640	4	5	245	349	37
Other heart disease (430–434)	1. 96	2	6	25	60	140	221	2	3	91	114	11
Underlying or contributory	2. 06	10	35	131	371	726	1, 245	13	13	509	661	49
Hypertension with heart disease (440–443)	1. 47	4	11	51	117	300	444	5	5	201	211	22
Underlying or contributory	1. 49	7	25	147	312	678	1, 220	8	11	558	592	51
Hypertension without heart disease (444–447)	1. 33	1	4	10	27	46	89	1	1	33	51	3
Underlying or contributory	1. 56	3	8	37	76	218	295	3	3	132	139	18
General arteriosclerosis (450)	1. 72	2	9	29	143	627	397	2	3	114	235	43
Underlying or contributory	1. 65	6	19	122	446	1, 606	1, 342	8	6	471	748	109
Nonsyphilitic aneurysm of aorta (451)	5. 15	1	2	30	128	225	384	1	1	131	235	16
Other circulatory disease (400–402, 452–468)	1. 63	6	—	19	37	80	161	8	—	79	67	7
Chronic nephritis, etc. (592–594)	1. 24	—	4	8	9	63	55	—	2	29	21	3
Underlying or contributory	1. 31	1	4	14	36	86	131	1	2	58	65	5
Diabetes mellitus (260)	1. 00	1	—	4	16	26	53	1	—	22	28	2
Underlying or contributory	1. 11	7	12	49	147	280	518	8	4	207	278	21
Paralysis agitans (350)	. 23	—	—	1	7	24	17	—	—	2	12	3
Underlying or contributory	. 30	—	—	2	16	98	46	—	—	10	27	9
Stomach ulcer (540)	4. 08	1	—	7	16	37	64	1	—	28	31	4
Underlying or contributory	3. 59	4	—	18	39	95	153	4	—	69	70	10
Duodenal ulcer (541)	3. 18	2	5	9	31	81	102	1	3	39	52	7
Underlying or contributory	4. 56	3	12	25	75	128	246	2	6	96	130	12
Cirrhosis of liver (581)	2. 78	3	8	29	52	59	215	4	4	95	107	5
Other diseases of liver, etc. (580, 582–587)	1. 49	1	7	9	13	29	67	1	3	32	29	2
Violence (800–962, 970–991)	1. 13	59	79	79	95	230	575	72	28	273	186	16
Ill-defined and unknown (780–795, XXX)†	1. 62	13	36	31	134	308	417	15	13	139	230	20
All other	1. 60	9	24	51	150	350	511	10	7	203	272	19

See footnotes at end of Appendix table A.

Appendix table A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

	CURRENT CIGARETTE SMOKERS—OCCASIONAL					
	Total 35–84	35–44	45–54	55–64	65–74	75–84
Person-years of observation:	30,129	3,657	1,283	14,624	10, 053	512

Cause of death (underlying cause unless otherwise specified, International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10⁵* 35–44	45–54	55–64	65–74	75–84	Number of deaths Total 35–84	35–44	45–54	55–64	65–74	75–84
All causes	1. 18	85	150	1, 280	2, 894	—	509	4	3	197	277	28
Cancer, all sites (140–205)	1. 20	—	—	236	463	—	93	—	—	40	47	6
Cancer of buccal cavity (140–144)	2. 89	—	—	4	6	—	2	—	—	1	1	—
Cancer of pharynx (145–148)	—	—	—	—	—	—	—	—	—	—	—	—
Cancer of esophagus (150)	5. 81	—	—	8	23	—	4	—	—	2	2	—
Cancer of stomach (151)	. 66	—	—	22	10	—	4	—	—	3	1	—
Cancer of intestines (152–153)	. 96	—	—	34	26	—	12	—	—	7	3	2
Cancer of rectum (154)	1. 14	—	—	30	26	—	7	—	—	3	4	—
Cancer of pancreas (157)	1. 10	—	—	13	41	—	6	—	—	3	3	—
Cancer of larynx (161)	—	—	—	—	—	—	—	—	—	—	—	—
Cancer of lung and bronchus (162–163)	3. 51	—	—	34	96	—	17	—	—	6	10	1
Cancer of prostate (177)	1. 28	—	—	8	53	—	9	—	—	2	6	1
Cancer of kidney (180)	. 41	—	—	—	24	—	1	—	—	—	1	—
Cancer of bladder and other (181)	. 63	—	—	—	23	—	2	—	—	—	2	—
Malignant lymphoma (200, 201, 203)	. 64	—	—	24	23	—	5	—	—	2	3	—
Leukemia (204)	1. 47	—	—	17	24	—	7	—	—	4	3	—
All other sites (155–156, 158–160, 164–165, 170–176, 178–179, 190–199, 202, 205)	1. 11	—	—	42	89	—	17	—	—	7	8	2
Bronchitis and/or emphysema	5. 79	—	—	16	118	—	11	—	—	4	7	—
Bronchitis (500–502)	—	—	—	—	—	—	—	—	—	—	—	—
Underlying or contributory	. 49	—	—	—	6	—	1	—	—	—	1	—
Emphysema without bronchitis (527.1)	9. 77	—	—	16	118	—	11	—	—	4	7	—
Underlying or contributory	5. 53	—	52	38	177	—	24	—	1	7	14	2
Respiratory tuberculosis (001–008)	1. 04	—	—	—	6	—	1	—	—	—	1	—
Underlying or contributory	1. 35	—	—	4	15	—	3	—	—	1	2	—

Asthma (241)	3. 41	—	—	18	—	—	2	—	—	2	—	—
Underlying or contributory	2. 02	—	—	28	—	—	5	—	—	4	—	1
Influenza and pneumonia (480–493)	—	—	—	—	—	—	—	—	—	—	—	—
Underlying or contributory	1. 43	—	—	62	302	—	42	—	—	12	27	3
Other respiratory disease (470–475, 510–526, 527.0, 527.2)	1. 54	—	—	9	14	—	4	—	—	1	2	1
Underlying or contributory	1. 25	—	—	31	62	—	11	—	—	4	6	1
Total cardiovascular disease (330–334, 400–468)	1. 12	42	150	771	1, 908	—	314	2	3	117	175	17
Cerebral vascular lesions (330–334)	1. 44	—	—	85	412	—	54	—	—	14	34	6
Underlying or contributory	1. 33	—	—	174	573	—	78	—	—	24	47	7
Chronic rheumatic heart disease (410–416)	1. 05	—	52	4	38	—	6	—	1	1	4	—
Underlying or contributory	1. 26	—	52	21	64	—	12	—	1	5	6	—
Arteriosclerotic (coronary) heart disease (420)	1. 05	42	52	569	1, 100	—	197	2	1	85	102	7
Underlying or contributory	1. 07	42	99	620	1, 308	—	233	2	2	92	124	13
Nonrheumatic endocarditis, etc. (421–422)	1. 23	—	—	4	103	—	10	—	—	1	9	—
Underlying or contributory	1. 45	—	—	18	205	—	25	—	—	4	19	2
Other heart disease (430–434)	1. 27	—	—	16	50	—	7	—	—	4	3	—
Underlying or contributory	1. 49	—	—	94	341	—	43	—	—	14	28	1
Hypertension with heart disease (440–443)	1. 06	—	47	34	82	—	15	—	1	5	7	2
Underlying or contributory	. 83	—	47	60	256	—	32	—	1	9	20	2
Hypertension without heart disease (444–447)	. 95	—	—	10	8	—	3	—	—	2	1	—
Underlying or contributory	1. 23	—	—	33	85	—	11	—	—	5	6	—
General arteriosclerosis (450)	1. 10	—	—	42	85	—	13	—	—	3	9	1
Underlying or contributory	. 80	—	—	67	202	—	33	—	—	8	21	4
Nonsyphilitic aneurysm of aorta (451)	1. 68	—	—	9	23	—	6	—	—	2	3	1
Other circulatory disease (400–402, 452–468)	. 63	—	—	—	19	—	3	—	—	—	3	—
Chronic nephritis, etc. (592–594)	. 49	—	—	—	10	—	1	—	—	—	1	—
Underlying or contributory	1. 09	—	—	4	33	—	5	—	—	1	4	—
Diabetes mellitus (260)	1. 15	—	—	9	8	—	3	—	—	2	1	—
Underlying or contributory	1. 24	—	—	62	176	—	28	—	—	7	17	4
Paralysis agitans (350)	. 86	—	—	—	29	—	3	—	—	—	3	—
Underlying or contributory	. 41	—	—	—	29	—	3	—	—	—	3	—
Stomach ulcer (540)	2. 72	—	—	22	—	—	2	—	—	2	—	—
Underlying or contributory	2. 50	—	—	26	23	—	5	—	—	3	2	—
Duodenal ulcer (541)	1. 28	—	—	4	8	—	2	—	—	1	1	—
Underlying or contributory	3. 03	—	—	19	35	—	8	—	—	4	4	—
Cirrhosis of liver (581)	1. 95	—	—	17	38	—	7	—	—	3	3	1
Other diseases of liver, etc. (580, 582–587)	1. 40	—	—	—	23	—	3	—	—	—	3	—
Violence (800–962, 970–991)	1. 40	43	—	96	110	—	31	2	—	13	15	1
Ill-defined and unknown (780–795, XXX)†	. 97	—	—	45	54	—	12	—	—	6	4	2
All other	1. 32	—	—	40	126	—	20	—	—	6	14	—

See footnotes at end of Appendix table A.

APPENDIX TABLE A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

CURRENT CIGARETTE SMOKERS—1-9/DAY

	Total 35-84	35-44	45-54	55-64	65-74	75-84
Person-years of observation:	95,462	8,063	3,129	45,217	37,130	1,923

Cause of death (underlying cause unless otherwise specified, International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10⁵* 35-44	45-54	55-64	65-74	75-84	Number of deaths Total 35-84	35-44	45-54	55-64	65-74	75-84
All causes	1.31	179	480	1,257	3,276	—	1,954	14	15	700	1,098	127
Cancer, all sites (140–205)	1.50	21	50	244	679	—	398	2	2	143	227	24
Cancer of buccal cavity (140–144)	2.12	—	—	4	5	—	5	—	—	3	2	—
Cancer of pharynx (145–148)	4.60	—	—	6	6	—	4	—	—	3	1	—
Cancer of esophagus (150)	2.53	—	—	6	—	—	6	—	—	4	—	2
Cancer of stomach (151)	1.69	—	—	19	60	—	35	—	—	13	21	1
Cancer of intestines (152–153)	1.12	—	19	27	101	—	48	—	1	12	32	3
Cancer of rectum (154)	1.02	—	—	25	45	—	21	—	—	10	11	—
Cancer of pancreas (157)	1.37	12	—	15	39	—	26	1	—	8	16	1
Cancer of larynx (161)	4.53	—	—	1	6	—	3	—	—	1	2	—
Cancer of lung and bronchus (162–163)	4.76	—	—	53	132	—	80	—	—	31	44	5
Cancer of prostate (177)	1.69	—	—	15	67	—	43	—	—	12	24	7
Cancer of kidney (180)	.72	—	—	5	4	—	6	—	—	4	2	—
Cancer of bladder and other (181)	.97	—	—	4	20	—	11	—	—	3	8	—
Malignant lymphoma (200, 201, 203)	1.10	10	—	18	46	—	29	1	—	10	17	1
Leukemia (204)	1.18	—	—	14	25	—	19	—	—	8	10	1
All other sites (155–156, 158–160, 164–165, 170–176, 178–179, 190–199, 202, 205)	1.20	—	30	33	125	—	62	—	1	21	37	3
Bronchitis and/or emphysema	4.14	—	—	12	60	—	28	—	—	9	18	1
Bronchitis (500–502)	2.13	—	—	2	16	—	6	—	—	2	4	—
Underlying or contributory	2.72	—	—	5	50	—	20	—	—	4	16	—
Emphysema without bronchitis (527.1)	5.58	—	—	9	44	—	22	—	—	7	14	1
Underlying or contributory	3.88	—	—	35	117	—	60	—	—	17	37	6
Respiratory tuberculosis (001–008)	2.30	—	—	4	9	—	8	—	—	3	4	1
Underlying or contributory	1.62	—	—	5	15	—	13	—	—	4	7	2

Asthma (241)	3. 12	—	—	1	10	—	6	—	—	1	4	1
Underlying or contributory	2. 49	—	—	8	63	—	21	—	—	5	15	1
Influenza and pneumonia (480–493)	1. 36	—	—	3	30	—	12	—	—	2	9	1
Underlying or contributory	1. 64	25	24	72	311	—	172	1	1	51	100	19
Other respiratory disease (470–475, 510–526, 527.0, 527.2)	1. 36	—	—	11	15	—	12	—	—	7	4	1
Underlying or contributory	1. 48	—	—	26	70	—	45	—	—	17	26	2
Total cardiovascular disease (330–334, 400–468)	1. 29	71	195	835	2, 147	—	1, 254	6	6	450	713	79
Cerebral vascular lesions (330–334)	1. 26	—	—	77	294	—	168	—	—	52	99	17
Underlying or contributory	1. 29	10	—	128	483	—	269	1	—	80	161	27
Chronic rheumatic heart disease (410–416)	1. 09	—	—	21	23	—	21	—	—	11	8	2
Underlying or contributory	1. 08	—	—	28	47	—	35	—	—	15	17	3
Arteriosclerotic (coronary) heart disease (420)	1. 26	41	195	594	1, 374	—	813	3	6	315	451	38
Underlying or contributory	1. 28	41	195	701	1, 677	—	965	3	6	366	541	49
Nonrheumatic endocarditis, etc. (421–422)	1. 30	—	—	17	89	—	37	—	—	11	25	1
Underlying or contributory	1. 35	—	—	67	156	—	81	—	—	30	49	2
Other heart disease (430–434)	1. 30	10	—	7	54	—	25	1	—	4	18	2
Underlying or contributory	1. 59	24	39	86	315	—	159	2	1	45	99	12
Hypertension with heart disease (440–443)	1. 56	10	—	47	123	—	76	1	—	25	45	5
Underlying or contributory	1. 27	10	—	96	285	—	168	1	—	52	106	9
Hypertension without heart disease (444–447)	1. 14	—	—	15	26	—	12	—	—	2	10	—
Underlying or contributory	1. 29	—	—	34	53	—	39	—	—	14	20	5
General arteriosclerosis (450)	1. 18	—	—	31	87	—	50	—	—	12	29	9
Underlying or contributory	1. 16	—	—	93	328	—	170	—	—	44	106	20
Nonsyphilitic aneurysm of aorta (451)	2. 16	—	—	12	60	—	27	—	—	8	16	3
Other circulatory disease (400–402, 452–468)	1. 51	10	—	15	32	—	25	1	—	10	12	2
Chronic nephritis, etc. (592–594)	. 87	—	—	5	5	—	6	—	—	3	2	1
Underlying or contributory	1. 10	—	—	10	36	—	17	—	—	4	11	2
Diabetes mellitus (260)	. 78	—	—	4	16	—	7	—	—	3	4	—
Underlying or contributory	. 96	—	—	33	134	—	76	—	—	23	49	4
Paralysis agitans (350)	. 16	—	—	—	5	—	2	—	—	—	2	—
Underlying or contributory	. 38	—	—	6	9	—	10	—	—	4	4	2
Stomach ulcer (540)	2. 71	—	—	9	6	—	7	—	—	4	3	—
Underlying or contributory	2. 17	—	—	11	18	—	15	—	—	6	9	—
Duodenal ulcer (541)	1. 68	—	—	8	9	—	9	—	—	4	3	2
Underlying or contributory	2. 11	—	—	12	33	—	19	—	—	7	10	2
Cirrhosis of liver (581)	2. 31	—	—	15	55	—	28	—	—	9	19	—
Other diseases of liver, etc. (580, 582–587)	. 53	—	39	4	—	—	4	—	1	3	—	—
Violence (800–962, 970–991)	. 77	33	99	45	75	—	55	3	3	24	24	1
Ill-defined and unknown (780–795, XXX)†	. 93	15	73	18	73	—	41	1	2	9	23	6
All other	1. 47	39	24	45	115	—	77	2	1	26	39	9

See footnotes at end of Appendix table A.

781-871—65——4

Appendix table A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

	CURRENT CIGARETTE SMOKERS—10-20/DAY					
	Total 35–84	35–44	45–54	55–64	65–74	75–84
Person-years of observation:	333,619	59,965	16,392	151,664	101,731	3,867

Cause of death (underlying cause unless otherwise specified, International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10⁵*					Number of deaths					
		35–44	45–54	55–64	65–74	75–84	Total 35–84	35–44	45–54	55–64	65–74	75–84
All causes	1. 68	214	645	1, 732	3, 980	8, 853	7, 308	131	96	3, 067	3, 696	318
Cancer, all sites (140–205)	1. 91	38	116	354	842	1, 484	1, 488	22	17	635	757	57
Cancer of buccal cavity (140–144)	2. 56	—	—	5	11	—	18	—	—	9	9	—
Cancer of pharynx (145–148)	8. 72	—	—	5	15	46	21	—	—	6	13	2
Cancer of esophagus (150)	3. 83	—	—	5	16	59	24	—	—	9	13	2
Cancer of stomach (151)	1. 42	3	24	20	41	83	87	2	3	35	44	3
Cancer of intestines (152–153)	1. 14	5	—	34	92	155	144	3	—	64	71	6
Cancer of rectum (154)	. 74	2	15	11	25	29	46	1	2	19	23	1
Cancer of pancreas (157)	1. 79	5	7	26	46	68	97	3	2	47	42	3
Cancer of larynx (161)	8. 33	—	—	5	12	34	16	—	—	6	9	1
Cancer of lung and bronchus (162–163)	9. 05	3	16	106	256	390	441	2	2	183	239	15
Cancer of prostate (177)	1. 80	—	—	19	86	285	123	—	—	43	71	9
Cancer of kidney (180)	1. 57	—	—	9	21	34	39	—	—	17	20	2
Cancer of bladder and other (181)	2. 29	—	9	12	43	110	71	—	1	25	40	5
Malignant lymphoma (200, 201, 203)	1. 14	6	4	24	48	40	90	3	1	40	44	2
Leukemia (204)	1. 54	3	9	19	48	134	75	1	1	32	36	5
All other sites (155–156, 158–160, 164–165, 170–176, 178–179, 190–199, 202, 205)	1. 24	12	32	54	85	26	196	7	5	100	83	1
Bronchitis and/or emphysema	8. 73	—	11	26	99	389	162	—	1	47	100	14
Bronchitis (500–502)	4. 34	—	—	5	22	103	34	—	—	6	24	4
Underlying or contributory	4. 17	—	—	12	58	280	87	—	—	21	55	11
Emphysema without bronchitis (527.1)	11. 94	—	11	20	78	286	128	—	1	41	76	10
Underlying or contributory	8. 40	5	26	47	264	559	355	3	3	97	229	23
Respiratory tuberculosis (001–008)	1. 98	—	—	7	9	—	19	—	—	10	9	—
Underlying or contributory	2. 68	—	5	21	25	—	60	—	1	32	27	—

Asthma (241)	2. 15	1	—	2	11	—	13	1	—	4	8	—
Underlying or contributory	2. 77	1	11	17	38	86	69	1	1	28	35	4
Influenza and pneumonia (480–493)	1. 66	2	11	4	26	204	40	1	1	9	24	5
Underlying or contributory	1. 84	11	25	97	343	1, 414	533	7	3	177	302	44
Other respiratory disease (470–475, 510–526, 527.0, 527.2)	1. 25	—	20	4	17	34	31	—	2	10	18	1
Underlying or contributory	2. 16	8	38	31	122	313	188	5	5	59	109	10
Total cardiovascular disease (330–334, 400–468)	1. 64	95	362	1, 127	2, 504	5, 620	4, 608	60	54	1, 987	2, 311	196
Cerebral vascular lesions (330–334)	1. 33	9	20	108	302	1, 155	490	6	3	189	254	38
Underlying or contributory	1. 36	13	51	168	512	1, 540	785	8	7	298	421	51
Chronic rheumatic heart disease (410–416)	1. 31	—	5	22	37	61	76	—	1	36	37	2
Underlying or contributory	1. 30	—	5	35	68	90	126	—	1	62	60	3
Arteriosclerotic (coronary) heart disease (420)	1. 64	73	297	830	1, 577	2, 791	3, 086	46	43	1, 424	1, 475	98
Underlying or contributory	1. 67	80	322	937	1, 919	3, 626	3, 631	50	47	1, 629	1, 777	128
Nonrheumatic endocarditis, etc. (421–422)	1. 68	3	—	22	85	251	134	2	—	45	80	7
Underlying or contributory	1. 90	6	—	65	192	833	323	4	—	123	170	26
Other heart disease (430–434)	2. 16	—	5	27	63	120	116	—	1	49	61	5
Underlying or contributory	2. 07	4	22	138	347	605	594	3	3	253	316	19
Hypertension with heart disease (440–443)	1. 34	—	9	45	110	262	192	—	2	87	94	9
Underlying or contributory	1. 49	4	33	134	313	756	577	2	6	247	296	26
Hypertension without heart disease (444–447)	1. 15	—	8	7	22	52	36	—	1	13	21	1
Underlying or contributory	1. 49	2	13	31	77	134	133	1	2	53	72	5
General arteriosclerosis (450)	1. 84	3	14	24	160	741	205	2	2	49	129	23
Underlying or contributory	1. 69	8	19	129	471	1, 713	663	5	3	219	378	58
Nonsyphilitic aneurysm of aorta (451)	5. 58	2	3	27	126	265	200	1	1	61	127	10
Other circulatory disease (400–402, 452–468)	1. 54	4	—	19	41	48	73	3	—	34	33	3
Chronic nephritis, etc. (592–594)	1. 19	—	3	7	8	29	25	—	1	15	8	1
Underlying or contributory	1. 17	2	3	12	31	29	55	1	1	26	26	1
Diabetes mellitus (260)	1. 07	—	—	4	16	54	27	—	—	9	16	2
Underlying or contributory	. 99	6	15	45	127	269	222	4	2	87	120	9
Paralysis agitans (350)	. 26	—	—	1	8	34	9	—	—	2	5	2
Underlying or contributory	. 29	—	—	2	17	89	21	—	—	5	12	4
Stomach ulcer (540)	4. 14	2	—	5	15	74	31	1	—	10	16	4
Underlying or contributory	3. 52	4	—	16	38	127	71	2	—	28	34	7
Duodenal ulcer (541)	3. 08	—	8	10	32	34	47	—	2	18	25	2
Underlying or contributory	5. 12	2	8	29	88	82	131	1	2	50	73	5
Cirrhosis of liver (581)	2. 56	1	5	28	47	84	93	1	1	41	47	3
Other diseases of liver, etc. (580, 582–587)	1. 39	—	3	9	11	60	30	—	1	14	13	2
Violence (800–962, 970–991)	1. 05	53	55	68	105	323	253	32	9	107	95	10
Ill-defined and unknown (780–795, XXX)†	1. 48	12	26	26	140	399	184	7	4	52	110	11
All other	1. 62	9	27	59	139	286	248	6	3	97	134	8

See footnotes at end of Appendix table A.

Appendix table A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

CURRENT CIGARETTE SMOKERS—21–39/DAY

	Total 35–84	35–44	45–54	55–64	65–74	75–84
Person-years of observation:	207, 821	40, 643	12, 839	103, 020	50, 045	1, 273

Cause of death (underlying cause unless otherwise specified, International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10⁵*					Number of deaths					
		35–44	45–54	55–64	65–74	75–84	Total 35–84	35–44	45–54	55–64	65–74	75–84
All causes	2. 00	269	902	2, 076	4, 794	—	4, 849	115	116	2, 409	2, 084	125
Cancer, all sites (140–205)	2. 69	48	218	517	1, 162	—	1, 183	18	26	615	495	29
Cancer of buccal cavity (140–144)	5. 90	—	—	9	15	—	24	—	—	11	11	2
Cancer of pharynx (145–148)	14. 35	—	—	9	16	—	18	—	—	9	8	1
Cancer of esophagus (150)	11. 88	2	—	14	26	—	38	1	—	18	15	4
Cancer of stomach (151)	1. 57	2	5	27	52	—	54	1	1	33	18	1
Cancer of intestines (152–153)	1. 31	2	24	43	87	—	94	1	2	48	41	2
Cancer of rectum (154)	1. 03	—	18	14	54	—	38	—	2	17	19	—
Cancer of pancreas (157)	2. 15	3	15	29	61	—	64	1	2	31	28	2
Cancer of larynx (161)	13. 26	—	—	6	12	—	16	—	—	7	8	1
Cancer of lung and bronchus (162–163)	16. 93	9	73	199	447	—	460	4	10	245	194	7
Cancer of prostate (177)	1. 52	—	12	16	74	—	52	—	1	21	29	1
Cancer of kidney (180)	1. 96	—	9	13	21	—	28	—	1	16	8	3
Cancer of bladder and other (181)	3. 15	—	12	19	73	—	51	—	1	25	24	1
Malignant lymphoma (200, 201, 203)	1. 30	6	21	29	54	—	60	2	2	31	25	—
Leukemia (204)	1. 62	6	—	28	33	—	45	2	—	26	16	1
All other sites (155–156, 158–160, 164–165, 170–176, 178–179, 190–199, 202, 205)	1. 54	17	30	64	142	—	141	6	4	77	51	3
Bronchitis and/or emphysema	11. 13	—	—	25	163	—	106	—	—	36	66	4
Bronchitis (500–502)	4. 01	—	—	3	28	—	16	—	—	5	11	—
Underlying or contributory	6. 05	2	7	24	104	—	65	1	1	26	34	3
Emphysema without bronchitis (527.1)	16. 27	—	—	22	135	—	90	—	—	31	55	4
Underlying or contributory	11. 49	7	37	66	393	—	250	3	4	84	144	15
Respiratory tuberculosis (001–008)	2. 21	—	—	4	13	—	11	—	—	5	6	—
Underlying or contributory	2. 40	—	17	11	33	—	28	—	2	12	13	1

Asthma (241)	3.92	—	24	7	7	—	15	—	2	9	4	—
Underlying or contributory	3.74	3	24	22	52	—	54	1	2	25	26	—
Influenza and pneumonia (480–493)	2.05	—	—	8	31	—	25	—	—	10	11	4
Underlying or contributory	2.19	8	14	130	401	—	330	4	2	154	156	14
Other respiratory disease (470–475, 510–526, 527.0, 527.2)	1.57	2	—	7	30	—	21	1	—	8	11	1
Underlying or contributory	2.44	4	35	43	153	—	114	2	4	48	58	2
Total cardiovascular disease (330–334, 400–468)	1.83	122	478	1,271	2,814	—	2,838	53	63	1,429	1,215	78
Cerebral vascular lesions (330–334)	1.54	10	31	115	356	—	296	4	4	131	143	14
Underlying or contributory	1.65	15	39	184	600	—	501	6	5	218	244	28
Chronic rheumatic heart disease (410–416)	.99	3	11	26	20	—	34	1	2	23	7	1
Underlying or contributory	1.13	3	16	37	53	—	63	1	3	35	20	4
Arteriosclerotic (coronary) heart disease (420)	1.82	88	390	912	1,701	—	1,917	39	50	1,019	776	33
Underlying or contributory	1.89	96	421	1,050	2,190	—	2,289	42	54	1,176	970	47
Nonrheumatic endocarditis, etc. (421–422)	1.81	—	22	26	111	—	78	—	3	26	44	5
Underlying or contributory	1.94	—	40	67	250	—	179	—	5	72	96	6
Other heart disease (430–434)	2.15	3	10	24	65	—	62	1	2	27	28	4
Underlying or contributory	2.40	16	61	139	444	—	379	7	9	165	184	14
Hypertension with heart disease (440–443)	1.73	9	5	62	141	—	140	4	1	70	59	6
Underlying or contributory	1.71	11	15	178	357	—	374	5	3	204	148	14
Hypertension without heart disease (444–447)	1.78	3	—	15	35	—	33	1	—	16	14	2
Underlying or contributory	1.73	6	5	43	77	—	89	2	1	49	31	6
General arteriosclerosis (450)	1.85	—	9	32	166	—	102	—	1	39	53	9
Underlying or contributory	2.00	6	31	136	503	—	399	3	3	169	200	24
Nonsyphilitic aneurysm of aorta (451)	6.55	—	—	41	203	—	126	—	—	50	74	2
Other circulatory disease (400–402, 452–468)	1.97	7	—	22	42	—	50	3	—	28	17	2
Chronic nephritis, etc. (592–594)	1.49	—	5	7	17	—	18	—	1	7	9	1
Underlying or contributory	1.48	—	5	14	41	—	41	—	1	18	20	2
Diabetes mellitus (260)	.96	3	—	6	13	—	13	1	—	8	4	—
Underlying or contributory	1.27	10	5	54	184	—	153	4	1	69	76	3
Paralysis agitans (350)	.06	—	—	—	1	—	1	—	—	—	1	—
Underlying or contributory	.21	—	—	—	14	—	8	—	—	—	7	1
Stomach ulcer (540)	4.11	—	—	6	25	—	17	—	—	8	9	—
Underlying or contributory	4.38	6	—	22	55	—	50	2	—	25	20	3
Duodenal ulcer (541)	4.44	4	5	8	61	—	37	1	1	10	22	3
Underlying or contributory	5.38	4	24	23	98	—	76	1	4	28	38	5
Cirrhosis of liver (581)	2.98	6	5	35	50	—	64	3	1	32	28	—
Other diseases of liver, etc. (580, 582–587)	2.05	2	—	11	27	—	24	1	—	11	12	—
Violence (800–962, 970–991)	1.28	65	103	92	88	—	190	29	13	101	44	3
Ill-defined and unknown (780–795, XXX)†	2.12	13	40	38	148	—	138	6	6	56	69	1
All other	1.77	4	27	48	222	—	148	2	3	64	78	1

See footnotes at end of Appendix table A.

Appendix table A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

CURRENT CIGARETTE SMOKERS—OVER 39/DAY

	Total 35–84	35–44	45–54	55–64	65–74	75–84
Person-years of observation:	34, 738	3, 992	1, 928	19, 649	8, 937	232

Cause of death (underlying cause unless otherwise specified, International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10⁵* 35–44	45–54	55–64	65–74	75–84	Number of deaths Total 35–84	35–44	45–54	55–64	65–74	75–84
All causes	2. 32	344	998	2, 640	5, 547	—	1, 024	15	20	555	414	20
Cancer, all sites (140–205)	3. 24	58	95	667	1, 278	—	260	3	2	142	109	4
Cancer of buccal cavity (140–144)	9. 26	—	—	19	15	—	7	—	—	5	2	—
Cancer of pharynx (145–148)	21. 71	—	—	12	26	—	5	—	—	2	3	—
Cancer of esophagus (150)	8. 38	—	—	13	7	—	5	—	—	4	1	—
Cancer of stomach (151)	1. 75	—	—	38	50	—	11	—	—	6	5	—
Cancer of intestines (152–153)	1. 13	—	—	32	121	—	15	—	—	8	7	—
Cancer of rectum (154)	1. 17	—	—	33	6	—	8	—	—	7	1	—
Cancer of pancreas (157)	2. 73	19	—	24	79	—	15	1	—	6	8	—
Cancer of larynx (161)	21. 17	—	—	14	29	—	5	—	—	3	2	—
Cancer of lung and bronchus (162–163)	23. 63	—	95	316	606	—	118	—	2	63	50	3
Cancer of prostate (177)	2. 42	—	—	38	59	—	15	—	—	10	5	—
Cancer of kidney (180)	2. 65	—	—	27	17	—	7	—	—	4	2	1
Cancer of bladder and other (181)	3. 03	—	—	22	70	—	9	—	—	5	4	—
Malignant lymphoma (200, 201, 203)	1. 06	—	—	32	7	—	9	—	—	8	1	—
Leukemia (204)	1. 40	38	—	9	22	—	7	2	—	2	3	—
All other sites (155–156, 158–160, 164–165, 170–176, 178–179, 190–199, 202, 205)	1. 47	—	—	38	171	—	24	—	—	9	15	—
Bronchitis and/or emphysema	15. 02	—	—	33	226	—	26	—	—	10	16	—
Bronchitis (500–502)	6. 91	—	—	6	30	—	5	—	—	2	3	—
Underlying or contributory	7. 38	—	—	36	52	—	14	—	—	8	6	—
Emphysema without bronchitis (527.1)	20. 86	—	—	27	196	—	21	—	—	8	13	—
Underlying or contributory	15. 95	—	—	89	575	—	63	—	—	23	37	3
Respiratory tuberculosis (001–008)	1. 10	—	—	4	—	—	1	—	—	1	—	—
Underlying or contributory	4. 24	—	25	25	78	—	9	—	1	6	2	—

Asthma (241)	5.53	—	—	20	8	—	4	—	—	3	1	—
Underlying or contributory	3.73	—	—	27	73	—	10	—	—	5	5	—
Influenza and pneumonia (480–493)	.91	—	—	3	23	—	2	—	—	1	1	—
Underlying or contributory	2.36	—	58	140	517	—	64	—	1	33	28	2
Other respiratory disease (470–475, 510–526, 527.0, 527.2)	2.50	—	—	16	12	—	6	—	—	4	1	1
Underlying or contributory	2.64	—	25	48	74	—	22	—	1	13	7	1
Total cardiovascular disease (330–334, 400–468)	1.99	114	548	1,543	3,260	—	566	5	11	312	227	11
Cerebral vascular lesions (330–334)	1.88	—	—	155	546	—	65	—	—	31	32	2
Underlying or contributory	1.94	19	—	271	697	—	107	1	—	60	43	3
Chronic rheumatic heart disease (410–416)	1.10	—	—	31	67	—	7	—	—	4	3	—
Underlying or contributory	1.06	—	—	39	80	—	11	—	—	6	5	—
Arteriosclerotic (coronary) heart disease (420)	1.97	94	502	1,101	1,955	—	382	4	10	221	139	8
Underlying or contributory	2.08	94	502	1,271	2,425	—	462	4	10	259	181	8
Nonrheumatic endocarditis, etc. (421–422)	1.64	—	—	44	95	—	13	—	—	7	6	—
Underlying or contributory	1.91	—	—	89	173	—	32	—	—	16	15	1
Other heart disease (430–434)	2.10	—	—	49	50	—	11	—	—	7	4	—
Underlying or contributory	2.41	28	—	164	591	—	70	1	—	32	34	3
Hypertension with heart disease (440–443)	1.41	—	48	52	77	—	21	—	1	14	6	—
Underlying or contributory	1.71	—	48	235	294	—	69	—	1	46	22	—
Hypertension without heart disease (444–447)	1.46	—	—	—	74	—	5	—	—	—	5	—
Underlying or contributory	2.41	—	—	60	164	—	23	—	—	11	10	2
General arteriosclerosis (450)	2.71	—	—	46	190	—	27	—	—	11	15	1
Underlying or contributory	2.13	—	—	120	729	—	77	—	—	31	43	3
Nonsyphilitic aneurysm of aorta (451)	7.21	—	—	41	226	—	25	—	—	10	15	—
Other circulatory disease (400–402, 452–468)	2.20	19	—	30	19	—	10	1	—	7	2	—
Chronic nephritis, etc. (592–594)	2.34	—	—	24	6	—	5	—	—	4	1	—
Underlying or contributory	2.57	—	—	41	49	—	13	—	—	9	4	—
Diabetes mellitus (260)	1.19	—	—	—	31	—	3	—	—	—	3	—
Underlying or contributory	1.77	—	48	78	240	—	39	—	1	21	16	1
Paralysis agitans (350)	.60	—	—	—	23	—	2	—	—	—	1	1
Underlying or contributory	.59	—	—	3	23	—	4	—	—	1	1	2
Stomach ulcer (540)	9.22	—	—	15	59	—	7	—	—	4	3	—
Underlying or contributory	5.67	—	—	27	99	—	12	—	—	7	5	—
Duodenal ulcer (541)	4.55	—	—	23	6	—	7	—	—	6	1	—
Underlying or contributory	4.60	—	—	29	38	—	12	—	—	7	5	—
Cirrhosis of liver (581)	5.77	—	106	40	122	—	23	—	2	10	10	1
Other diseases of liver, etc. (580, 582–587)	2.78	—	25	22	7	—	6	—	1	4	1	—
Violence (800–962, 970–991)	1.81	149	154	145	93	—	46	6	3	28	8	1
Ill-defined and unknown (780–795, XXX)†	3.57	24	76	66	374	—	42	1	1	16	24	—
All other	1.20	—	—	39	126	—	18	—	—	10	7	1

See footnotes at end of Appendix table A.

APPENDIX TABLE A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

CURRENT SMOKERS OF CIGARETTES ONLY—TOTAL

	Total 35–84	35–44	45–54	55–64	65–74	75–84
Person-years of observation:	440,935	81,759	23,795	208,365	123,110	3,906

Cause of death (underlying cause unless otherwise specified, International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10⁵*					Number of deaths					
		35–44	45–54	55–64	65–74	75–84	Total 35–84	35–44	45–54	55–64	65–74	75–84
All causes	1.84	222	758	1,942	4,313	9,581	10,127	190	172	4,627	4,786	352
Cancer, all sites(140–205)	2.21	39	158	434	920	1,796	2,193	32	35	1,049	1,009	68
Cancer of buccal cavity (140–144)	4.09	—	—	8	11	26	37	—	—	19	16	2
Cancer of pharynx (145–148)	12.54	—	—	7	19	89	37	—	—	14	20	3
Cancer of esophagus (150)	6.17	1	—	8	15	116	47	1	—	23	18	5
Cancer of stomach (151)	1.60	2	3	26	51	168	124	2	1	60	57	4
Cancer of intestines (152–153)	1.27	5	10	40	94	187	205	4	2	96	96	7
Cancer of rectum (154)	.98	1	14	18	42	—	79	1	3	37	38	—
Cancer of pancreas (157)	1.84	5	13	24	49	69	125	4	4	61	54	2
Cancer of larynx (161)	9.95	—	—	5	13	35	25	—	—	11	13	1
Cancer of lung and bronchus (162–163)	12.14	6	36	158	300	449	749	5	9	380	337	18
Cancer of prostate (177)	1.80	—	7	19	81	353	149	—	1	56	82	10
Cancer of kidney (180)	1.45	—	—	9	16	46	46	—	—	25	19	2
Cancer of bladder and other (181)	2.15	—	13	12	43	82	82	—	2	31	44	5
Malignant lymphoma (200, 201, 203)	1.24	7	16	26	46	20	126	5	3	60	57	1
Leukemia (204)	1.38	2	7	21	40	75	86	2	1	37	42	4
All other sites (155–156, 158–160, 164–165, 170–176, 178–179, 190–199, 202, 205)	1.35	11	39	54	105	94	276	8	9	139	116	4
Bronchitis and/or emphysema	10.08	—	7	29	113	280	229	—	1	84	133	11
Bronchitis (500–502)	4.49	—	—	4	23	56	43	—	—	12	29	2
Underlying or contributory	4.65	1	—	18	62	184	119	1	—	41	69	8
Emphysema without bronchitis (527.1)	14.17	—	7	25	90	224	186	—	1	72	104	9
Underlying or contributory	9.87	5	31	64	301	650	511	4	6	167	308	26
Respiratory tuberculosis (001–008)	2.12	—	—	3	14	—	25	—	—	9	16	—
Underlying or contributory	2.76	—	14	14	34	48	76	—	3	34	37	2

Asthma (241)	3.47	1	7	7	10	—	28	1	1	15	11	—
Underlying or contributory	3.53	3	14	19	56	111	113	2	2	50	54	5
Influenza and pneumonia (480–493)	1.87	1	7	6	33	251	55	1	1	16	30	7
Underlying or contributory	2.14	13	22	117	410	1,437	761	11	5	296	404	45
Other respiratory disease (470–475, 510–526, 527.0, 527.2)	1.52	—	7	7	24	88	47	—	1	20	23	3
Underlying or contributory	2.13	4	17	36	117	319	230	4	3	88	124	11
Total cardiovascular disease (330–334, 400–468)	1.75	103	407	1,227	2,679	6,036	6,211	89	92	2,861	2,950	219
Cerebral vascular lesions (330–334)	1.52	11	8	118	341	1,429	692	9	2	285	350	46
Underlying or contributory	1.55	16	27	185	551	2,045	1,107	13	6	456	565	67
Chronic rheumatic heart disease (410–416)	1.19	—	3	28	34	122	90	—	1	52	33	4
Underlying or contributory	1.21	—	3	39	65	184	150	—	1	79	63	7
Arteriosclerotic (coronary) heart disease (420)	1.74	80	353	880	1,659	2,683	4,150	70	78	2,031	1,870	101
Underlying or contributory	1.78	86	377	1,001	2,073	3,530	4,910	75	83	2,339	2,281	132
Nonrheumatic endocarditis, etc. (421–422)	1.87	1	6	29	106	351	187	1	2	64	110	10
Underlying or contributory	1.95	2	11	68	216	746	414	2	3	161	225	23
Other heart disease (430–434)	2.17	—	6	29	65	167	145	—	2	62	76	5
Underlying or contributory	2.26	8	30	150	385	801	817	7	8	362	412	28
Hypertension with heart disease (440–443)	1.67	4	9	52	147	441	303	3	2	133	150	15
Underlying or contributory	1.60	7	27	153	339	956	786	6	7	360	380	33
Hypertension without heart disease (444–447)	1.41	1	6	12	31	20	57	1	1	23	31	1
Underlying or contributory	1.81	4	9	44	92	254	207	3	2	96	95	11
General arteriosclerosis (450)	1.86	1	14	30	153	652	249	1	3	75	147	23
Underlying or contributory	1.84	5	26	135	497	1,815	880	5	5	321	488	61
Nonsyphilitic aneurysm of aorta (451)	5.24	2	2	33	123	168	234	1	1	84	140	8
Other circulatory disease (400–402, 452–468)	1.77	4	—	20	43	143	104	3	—	52	43	6
Chronic nephritis, etc. (592–594)	1.42	—	3	9	7	133	38	—	1	22	12	3
Underlying or contributory	1.33	—	3	15	29	133	81	—	1	40	37	3
Diabetes mellitus (260)	.95	2	—	4	15	35	30	1	—	13	15	1
Underlying or contributory	1.10	9	4	52	134	284	308	7	1	137	152	11
Paralysis agitans (350)	.26	—	—	1	6	46	11	—	—	1	7	3
Underlying or contributory	.35	—	—	2	19	158	31	—	—	5	19	7
Stomach ulcer (540)	4.13	—	—	7	17	26	39	—	—	19	19	1
Underlying or contributory	4.13	3	—	19	46	98	106	2	—	50	49	5
Duodenal ulcer (541)	2.98	—	5	8	29	122	57	—	2	19	31	5
Underlying or contributory	4.87	—	12	25	83	182	157	—	4	58	87	8
Cirrhosis of liver (581)	3.33	3	13	37	61	43	156	3	4	74	74	1
Other diseases of liver, etc. (580, 582–587)	1.59	1	2	7	15	35	43	1	1	21	19	1
Violence (800–962, 970–991)	1.19	50	89	84	105	297	379	44	20	185	120	10
Ill-defined and unknown (780–795, XXX)†	1.75	15	46	33	152	324	269	12	11	89	147	10
All other	1.65	8	9	51	169	359	317	6	2	130	170	9

See footnotes at end of Appendix table A.

APPENDIX TABLE A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

	CURRENT SMOKERS OF CIGARETTES ONLY—OCCASIONAL					
	Total 35–84	35–44	45–54	55–64	65–74	75–84
Person-years of observation:	9,043	1,254	402	4,397	2,874	114

Cause of death (underlying cause unless otherwise specified, International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10⁵*					Number of deaths					
		35–44	45–54	55–64	65–74	75–84	Total 35–84	35–44	45–54	55–64	65–74	75–84
All causes	1. 06	—	—	1, 141	—	—	132	—	—	59	68	5
Cancer, all sites (140–205)	1. 03	—	—	294	—	—	23	—	—	14	8	1
Cancer of buccal cavity (140–144)	—	—	—	—	—	—	—	—	—	—	—	—
Cancer of pharynx (145–148)	—	—	—	—	—	—	—	—	—	—	—	—
Cancer of esophagus (150)	—	—	—	—	—	—	—	—	—	—	—	—
Cancer of stomach (151)	. 58	—	—	45	—	—	1	—	—	1	—	—
Cancer of intestines (152–153)	1. 67	—	—	85	—	—	6	—	—	5	1	—
Cancer of rectum (154)	1. 12	—	—	81	—	—	2	—	—	2	—	—
Cancer of pancreas (157)	1. 28	—	—	13	—	—	2	—	—	1	1	—
Cancer of larynx (161)	—	—	—	—	—	—	—	—	—	—	—	—
Cancer of lung and bronchus (162–163)	2. 85	—	—	13	—	—	4	—	—	1	2	1
Cancer of prostate (177)	. 51	—	—	—	—	—	1	—	—	—	1	—
Cancer of kidney (180)	—	—	—	—	—	—	—	—	—	—	—	—
Cancer of bladder and other (181)	—	—	—	—	—	—	—	—	—	—	—	—
Malignant lymphoma (200, 201, 203)	. 89	—	—	13	—	—	2	—	—	1	1	—
Leukemia (204)	. 72	—	—	13	—	—	1	—	—	1	—	—
All other sites (155–156, 158–160, 164–165, 170–176, 178–179, 190–199, 202, 205)	. 90	—	—	32	—	—	4	—	—	2	2	—
Bronchitis and/or emphysema	7. 43	—	—	41	—	—	4	—	—	3	1	—
Bronchitis (500–502)	—	—	—	—	—	—	—	—	—	—	—	—
Underlying or contributory	—	—	—	—	—	—	—	—	—	—	—	—
Emphysema without bronchitis (527.1)	12. 53	—	—	41	—	—	4	—	—	3	1	—
Underlying or contributory	4. 06	—	—	41	—	—	5	—	—	3	1	1
Respiratory tuberculosis (001–008)	3. 66	—	—	—	—	—	1	—	—	—	1	—
Underlying or contributory	3. 15	—	—	13	—	—	2	—	—	1	1	—

Asthma (241)	11. 51	—	—	60	—	—	2	—	—	2	—	—
Underlying or contributory	4. 19	—	—	60	—	—	3	—	—	2	—	1
Influenza and pneumonia (480–493)	—	—	—	—	—	—	—	—	—	—	—	—
Underlying or contributory	2. 05	—	—	112	—	—	17	—	—	6	11	—
Other respiratory disease (470–475, 510–526, 527.0, 527.2)	—	—	—	—	—	—	—	—	—	—	—	—
Underlying or contributory	. 80	—	—	—	—	—	2	—	—	—	2	—
Total cardiovascular disease (330–334, 400–468)	1. 00	—	—	643	—	—	81	—	—	33	45	3
Cerebral vascular lesions (330–334)	1. 61	—	—	154	—	—	17	—	—	5	10	2
Underlying or contributory	1. 33	—	—	215	—	—	22	—	—	8	12	2
Chronic rheumatic heart disease (410–416)	. 60	—	—	13	—	—	1	—	—	1	—	—
Underlying or contributory	. 72	—	—	13	—	—	2	—	—	1	1	—
Arteriosclerotic (coronary) heart disease (420)	. 94	—	—	391	—	—	51	—	—	21	29	1
Underlying or contributory	. 94	—	—	474	—	—	59	—	—	25	33	1
Nonrheumatic endocarditis, etc. (421–422)	. 87	—	—	—	—	—	2	—	—	—	2	—
Underlying or contributory	1. 63	—	—	15	—	—	8	—	—	1	6	1
Other heart disease (430–434)	. 64	—	—	13	—	—	1	—	—	1	—	—
Underlying or contributory	. 85	—	—	41	—	—	7	—	—	3	4	—
Hypertension with heart disease (440–443)	. 24	—	—	—	—	—	1	—	—	—	1	—
Underlying or contributory	. 72	—	—	56	—	—	8	—	—	3	5	—
Hypertension without heart disease (444–447)	2. 18	—	—	18	—	—	2	—	—	1	1	—
Underlying or contributory	1. 94	—	—	63	—	—	5	—	—	2	3	—
General arteriosclerosis (450)	. 61	—	—	26	—	—	2	—	—	2	—	—
Underlying or contributory	. 26	—	—	26	—	—	3	—	—	2	1	—
Nonsyphilitic aneurysm of aorta (451)	3. 93	—	—	29	—	—	4	—	—	2	2	—
Other circulatory disease (400–402, 452–468)	—	—	—	—	—	—	—	—	—	—	—	—
Chronic nephritis, etc. (592–594)	—	—	—	—	—	—	—	—	—	—	—	—
Underlying or contributory	1. 50	—	—	13	—	—	2	—	—	1	1	—
Diabetes mellitus (260)	1. 36	—	—	—	—	—	1	—	—	—	1	—
Underlying or contributory	. 93	—	—	46	—	—	6	—	—	3	3	—
Paralysis agitans (350)	1. 02	—	—	—	—	—	1	—	—	—	1	—
Underlying or contributory	. 49	—	—	—	—	—	1	—	—	—	1	—
Stomach ulcer (540)	—	—	—	—	—	—	—	—	—	—	—	—
Underlying or contributory	1. 73	—	—	—	—	—	1	—	—	—	1	—
Duodenal ulcer (541)	—	—	—	—	—	—	—	—	—	—	—	—
Underlying or contributory	1. 32	—	—	—	—	—	1	—	—	—	1	—
Cirrhosis of liver (581)	. 97	—	—	—	—	—	1	—	—	—	1	—
Other diseases of liver, etc. (580, 582–587)	1. 64	—	—	—	—	—	1	—	—	—	1	—
Violence (800–962, 970–991)	1. 81	—	—	82	—	—	12	—	—	5	6	1
Ill-defined and unknown (780–795, XXX)†	. 28	—	—	—	—	—	1	—	—	—	1	—
All other	. 93	—	—	26	—	—	4	—	—	2	2	—

See footnotes at end of Appendix table A.

Appendix table A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

	CURRENT SMOKERS OF CIGARETTES ONLY—1-9/DAY					
	Total 35–84	35–44	45–54	55–64	65–74	75–84
Person-years of observation:	48,225	5,182	1,763	22,237	18,174	869

Cause of death (underlying cause unless otherwise specified, International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10⁵*					Number of deaths					
		35–44	45–54	55–64	65–74	75–84	Total 35–84	35–44	45–54	55–64	65–74	75–84
All causes	1. 45	163	623	1, 435	3, 576	—	1, 057	7	11	389	586	64
Cancer, all sites (140–205)	1. 56	15	89	274	708	—	202	1	2	78	114	7
Cancer of buccal cavity (140–144)	. 86	—	—	3	—	—	1	—	—	1	—	—
Cancer of pharynx (145–148)	7. 11	—	—	9	12	—	3	—	—	2	1	—
Cancer of esophagus (150)	1. 76	—	—	2	—	—	2	—	—	1	—	1
Cancer of stomach (151)	2. 17	—	—	27	68	—	22	—	—	9	12	1
Cancer of intestines (152–153)	1. 28	—	36	11	125	—	27	—	1	4	20	2
Cancer of rectum (154)	1. 59	—	—	47	70	—	16	—	—	8	8	—
Cancer of pancreas (157)	. 87	—	—	15	29	—	8	—	—	4	4	—
Cancer of larynx (161)	3. 27	—	—	—	7	—	1	—	—	—	1	—
Cancer of lung and bronchus (162–163)	5. 49	—	—	70	135	—	45	—	—	22	22	1
Cancer of prostate (177)	1. 38	—	—	21	40	—	17	—	—	8	8	1
Cancer of kidney (180)	. 97	—	—	5	7	—	4	—	—	2	2	—
Cancer of bladder and other (181)	1. 10	—	—	2	25	—	6	—	—	1	5	—
Malignant lymphoma (200, 201, 203)	1. 17	15	—	29	36	—	15	1	—	7	7	—
Leukemia (204)	. 88	—	—	4	29	—	7	—	—	1	6	—
All other sites (155–156, 158–160, 164–165, 170–176, 178–179, 190–199, 202, 205)	1. 10	—	52	29	126	—	28	—	1	8	18	1
Bronchitis and/or emphysema	4. 61	—	—	12	66	—	15	—	—	5	10	—
Bronchitis (500–502)	3. 63	—	—	5	15	—	5	—	—	2	3	—
Underlying or contributory	3. 61	—	—	10	54	—	13	—	—	4	9	—
Emphysema without bronchitis (527.1)	5. 33	—	—	7	52	—	10	—	—	3	7	—
Underlying or contributory	4. 84	—	—	45	173	—	36	—	—	8	25	3
Respiratory tuberculosis (001–008)	1. 78	—	—	2	9	—	3	—	—	1	2	—
Underlying or contributory	2. 05	—	—	5	22	—	8	—	—	2	5	1

Asthma (241)	3. 18	—	—	—	12	—	3	—	—	—	3	—
Underlying or contributory	3. 17	—	—	14	76	—	13	—	—	4	9	—
Influenza and pneumonia (480–493)	1. 62	—	—	5	34	—	7	—	—	2	5	—
Underlying or contributory	1. 87	36	—	81	339	—	95	1	—	28	55	11
Other respiratory disease (470–475, 510–526, 527.0, 527.2)	1. 40	—	—	12	26	—	6	—	—	3	3	—
Underlying or contributory	1. 35	—	—	22	84	—	20	—	—	7	12	1
Total cardiovascular disease (330–334, 400–468)	1. 45	64	354	956	2, 326	—	688	3	6	250	384	45
Cerebral vascular lesions (330–334)	1. 51	—	—	92	323	—	98	—	—	32	53	13
Underlying or contributory	1. 45	—	—	152	514	—	147	—	—	47	84	16
Chronic rheumatic heart disease (410–416)	1. 06	—	—	26	13	—	10	—	—	6	3	1
Underlying or contributory	. 88	—	—	32	30	—	14	—	—	7	6	1
Artheriosclerotic (coronary) heart disease (420)	1. 39	64	354	685	1, 406	—	439	3	6	176	237	17
Underlying or contributory	1. 44	64	354	808	1, 813	—	528	3	6	204	293	22
Nonrheumatic endocarditis, etc. (421–422)	1. 67	—	—	13	136	—	23	—	—	5	17	1
Underlying or contributory	1. 41	—	—	36	197	—	41	—	—	12	27	2
Other heart disease (430–434)	1. 39	—	—	8	55	—	13	—	—	2	10	1
Underlying or contributory	1. 74	24	—	63	371	—	85	1	—	20	56	8
Hypertension with heart disease (440–443)	2. 06	—	—	42	185	—	49	—	—	14	32	3
Underlying or contributory	1. 52	—	—	113	348	—	98	—	—	31	62	5
Hypertension without heart disease (444–447)	1. 57	—	—	31	37	—	8	—	—	2	6	—
Underlying or contributory	1. 62	—	—	58	77	—	24	—	—	10	12	2
General arteriosclerosis (450)	1. 08	—	—	33	93	—	22	—	—	4	12	6
Underlying or contributory	1. 23	—	—	98	374	—	87	—	—	22	52	13
Nonsyphilitic aneurysm of aorta (451)	2. 12	—	—	13	57	—	13	—	—	4	8	1
Other circulatory disease (400–402, 452–468)	1. 62	—	—	15	37	—	13	—	—	5	6	2
Chronic nephritis, etc. (592–594)	. 59	—	—	3	—	—	2	—	—	1	—	1
Underlying or contributory	. 79	—	—	3	20	—	6	—	—	1	4	1
Diabetes mellitus (260)	. 68	—	—	3	21	—	3	—	—	1	2	—
Underlying or contributory	. 62	—	—	22	85	—	24	—	—	7	15	2
Paralysis agitans (350)	. 16	—	—	—	4	—	1	—	—	—	1	—
Underlying or contributory	. 47	—	—	5	12	—	6	—	—	2	3	1
Stomach ulcer (540)	3. 95	—	—	12	7	—	5	—	—	3	2	—
Underlying or contributory	3. 27	—	—	17	26	—	11	—	—	5	6	—
Duodenal ulcer (541)	2. 30	—	—	14	12	—	6	—	—	3	2	1
Underlying or contributory	2. 73	—	—	16	55	—	12	—	—	4	7	1
Cirrhosis of liver (581)	2. 72	—	—	12	74	—	16	—	—	5	11	—
Other diseases of liver, etc. (580, 582–587)	. 54	—	—	5	—	—	2	—	—	2	—	—
Violence (800–962, 970–991)	. 81	—	52	54	104	—	29	—	1	13	14	1
Ill-defined and unknown (780–795, XXX)†	1. 25	24	129	25	101	—	27	1	2	5	15	4
All other	1. 64	60	—	51	109	—	42	2	—	17	18	5

See footnotes at end of Appendix table A.

APPENDIX TABLE A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

CURRENT SMOKERS OF CIGARETTES ONLY—10–20/DAY

	Total 35–84	35–44	45–54	55–64	65–74	75–84
Person-years of observation:	217,776	43,525	11,427	97,446	63,274	2,104

Cause of death (underlying cause unless otherwise specified, International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10⁵* 35–44	45–54	55–64	65–74	75–84	Number of deaths Total 35–84	35–44	45–54	55–64	65–74	75–84
All causes	1. 80	199	664	1, 850	4, 226	—	4, 926	90	67	2, 117	2, 458	194
Cancer, all sites (140–205)	2. 04	41	123	376	863	—	1, 003	17	13	444	486	43
Cancer of buccal cavity (140–144)	2. 93	—	—	6	10	—	13	—	—	7	6	—
Cancer of pharynx (145–148)	12. 81	—	—	8	22	—	19	—	—	6	11	2
Cancer of esophagus (150)	4. 71	—	—	5	16	—	18	—	—	8	8	2
Cancer of stomach (151)	1. 61	2	7	21	48	—	62	1	1	25	32	3
Cancer of intestines (152–153)	1. 18	7	—	33	88	—	94	3	—	42	45	4
Cancer of rectum (154)	. 84	2	9	14	32	—	33	1	1	13	18	—
Cancer of pancreas (157)	1. 93	6	9	24	50	—	65	3	2	32	27	1
Cancer of larynx (161)	8. 45	—	—	4	13	—	10	—	—	4	5	1
Cancer of lung and bronchus (162–163)	9. 91	2	24	123	265	—	303	1	2	139	149	12
Cancer of prostate (177)	2. 12	—	—	23	98	—	89	—	—	31	50	8
Cancer of kidney (180)	1. 34	—	—	8	15	—	21	—	—	10	10	1
Cancer of bladder and other (181)	1. 93	—	13	12	28	—	37	—	1	13	19	4
Malignant lymphoma (200, 201, 203)	1. 26	9	6	23	52	—	63	3	1	27	31	1
Leukemia (204)	1. 40	—	14	18	45	—	43	—	1	18	21	3
All other sites (155–156, 158–160, 164–165, 170–176, 178–179, 190–199, 202, 205)	1. 32	13	41	55	85	—	133	5	4	69	54	1
Bronchitis and/or emphysema	10. 00	—	16	32	100	—	115	—	1	38	68	8
Bronchitis (500–502)	4. 51	—	—	5	22	—	22	—	—	4	16	2
Underlying or contributory	4. 06	—	—	12	49	—	53	—	—	14	32	7
Emphysema without bronchitis (527.1)	14. 04	—	16	27	78	—	93	—	1	34	52	6
Underlying or contributory	9. 52	5	39	56	285	—	249	2	3	74	156	14
Respiratory tuberculosis (001–008)	2. 01	—	—	3	14	—	12	—	—	4	8	—
Underlying or contributory	2. 73	—	8	16	30	—	38	—	1	18	19	—

Asthma (241)	2. 34	2	—	2	11	—	9	1	—	4	4	—
Underlying or contributory	3. 12	2	16	14	44	—	49	1	1	20	23	4
Influenza and pneumonia (480–493)	1. 95	2	16	4	34	—	29	1	1	5	18	4
Underlying or contributory	2. 09	15	23	103	415	—	376	7	2	126	218	23
Other respiratory disease (470–475, 510–526, 527.0, 527.2)	1. 43	—	16	4	21	—	22	—	1	6	14	1
Underlying or contributory	2. 28	6	37	32	123	—	124	3	3	37	73	8
Total cardiovascular disease (330–334, 400–468)	1. 77	94	361	1, 219	2, 700	—	3, 120	43	37	1, 374	1, 554	112
Cerebral vascular lesions (330–334)	1. 42	13	—	112	312	—	325	6	—	133	167	19
Underlying or contributory	1. 45	17	33	174	520	—	520	8	3	211	272	26
Chronic rheumatic heart disease (410–416)	1. 44	—	—	26	43	—	53	—	—	27	24	2
Underlying or contributory	1. 41	—	—	41	76	—	86	—	—	46	37	3
Arteriosclerotic (coronary) heart disease (420)	1. 78	70	316	902	1, 702	—	2, 102	32	32	986	995	57
Underlying or contributory	1. 80	75	332	1, 006	2, 061	—	2, 451	34	33	1, 125	1, 182	77
Nonrheumatic endocarditis, etc. (421–422)	1. 75	2	—	22	89	—	87	1	—	29	53	4
Underlying or contributory	1. 99	4	—	69	191	—	211	2	—	82	112	15
Other heart disease (430–434)	2. 57	—	7	31	78	—	86	—	1	34	49	2
Underlying or contributory	2. 32	4	7	163	364	—	416	2	1	190	213	10
Hypertension with heart disease (440–443)	1. 55	—	—	50	137	—	139	—	—	61	69	9
Underlying or contributory	1. 57	5	28	139	331	—	381	2	3	159	196	21
Hypertension without heart disease (444–447)	1. 07	—	12	8	20	—	21	—	1	10	10	—
Underlying or contributory	1. 71	2	19	31	92	—	96	1	2	39	51	3
General arteriosclerosis (450)	1. 97	2	21	26	174	—	134	1	2	32	88	11
Underlying or contributory	1. 88	4	21	157	507	—	454	2	2	163	256	31
Nonsyphilitic aneurysm of aorta (451)	5. 53	3	5	27	123	—	124	1	1	39	77	6
Other circulatory disease (400–402, 452–468)	1. 66	4	—	18	46	—	49	2	—	23	22	2
Chronic nephritis, etc. (592–594)	1. 28	—	—	9	5	—	17	—	—	12	4	1
Underlying or contributory	1. 17	—	—	14	27	—	35	—	—	19	15	1
Diabetes mellitus (260)	. 90	—	—	3	13	—	14	—	—	5	8	1
Underlying or contributory	1. 03	9	8	50	128	—	144	4	1	60	73	6
Paralysis agitans (350)	. 33	—	—	1	7	—	7	—	—	1	4	2
Underlying or contributory	. 35	—	—	2	21	—	16	—	—	2	10	4
Stomach ulcer (540)	2. 77	—	—	3	9	—	13	—	—	4	8	1
Underlying or contributory	3. 55	3	—	16	37	—	45	1	—	19	22	3
Duodenal ulcer (541)	2. 74	—	6	9	21	—	26	—	1	9	14	2
Underlying or contributory	5. 40	—	6	31	92	—	86	—	1	32	50	3
Cirrhosis of liver (581)	3. 15	2	7	35	57	—	72	1	1	34	35	1
Other diseases of liver, etc. (580, 582–587)	1. 49	—	5	6	14	—	20	—	1	9	9	1
Violence (800–962, 970–991)	1. 08	38	64	76	106	—	170	18	6	75	64	7
Ill-defined and unknown (780–795, XXX)†	1. 53	15	38	25	153	—	118	6	4	32	70	6
All other	1. 66	6	16	54	150	—	159	3	1	61	90	4

See footnotes at end of Appendix table A.

Appendix table A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

	CURRENT SMOKERS OF CIGARETTES ONLY—21–39/DAY					
	Total 35–84	35–44	45–54	55–64	65–74	75–84
Person-years of observation:	141,785	28,979	8,929	70,327	32,852	699

Cause of death (underlying cause unless otherwise specified, International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10⁵*					Number of deaths					
		35–44	45–54	55–64	65–74	75–84	Total 35–84	35–44	45–54	55–64	65–74	75–84
All causes	2.05	266	891	2,087	4,940	—	3,313	83	80	1,656	1,416	78
Cancer, all sites (140–205)	2.70	42	227	514	1,179	—	794	12	19	413	335	15
Cancer of buccal cavity (140–144)	7.34	—	—	12	19	—	20	—	—	9	9	2
Cancer of pharynx (145–148)	14.59	—	—	8	10	—	12	—	—	6	5	1
Cancer of esophagus (150)	11.50	3	—	14	25	—	24	1	—	12	9	2
Cancer of stomach (151)	1.35	3	—	24	58	—	31	1	—	19	11	—
Cancer of intestines (152–153)	1.36	3	17	52	81	—	65	1	1	38	24	1
Cancer of rectum (154)	.97	—	26	11	53	—	24	—	2	10	12	—
Cancer of pancreas (157)	2.18	5	21	26	56	—	43	1	2	20	19	1
Cancer of larynx (161)	13.62	—	—	5	17	—	11	—	—	4	7	—
Cancer of lung and bronchus (162–163)	17.41	13	52	205	432	—	315	4	6	171	131	3
Cancer of prostate (177)	1.53	—	18	11	90	—	34	—	1	11	21	1
Cancer of kidney (180)	1.68	—	—	10	27	—	16	—	—	10	6	—
Cancer of bladder and other (181)	3.20	—	18	14	96	—	34	—	1	14	18	1
Malignant lymphoma (200, 201, 203)	1.26	4	31	28	51	—	39	1	2	19	17	—
Leukemia (204)	1.61	—	—	30	44	—	30	—	—	16	13	1
All other sites (155–156, 158–160, 164–165, 170–176, 178–179, 190–199, 202, 205)	1.56	12	43	65	126	—	96	3	4	54	33	2
Bronchitis and/or emphysema	11.81	—	—	30	141	—	74	—	—	30	41	3
Bronchitis (500–502)	4.57	—	—	5	30	—	12	—	—	5	7	—
Underlying or contributory	5.91	3	—	24	103	—	42	1	—	18	22	1
Emphysema without bronchitis (527.1)	17.04	—	—	26	111	—	62	—	—	25	34	3
Underlying or contributory	12.23	6	37	77	394	—	175	2	3	65	99	6
Respiratory tuberculosis (001–008)	2.44	—	—	3	19	—	8	—	—	3	5	—
Underlying or contributory	2.60	—	25	9	41	—	20	—	2	7	10	1

Asthma (241)	4.25	—	17	8	9	—	11	—	1	7	3	—
Underlying or contributory	4.04	5	17	22	55	—	39	1	1	20	17	—
Influenza and pneumonia (480–493)	2.25	—	—	11	35	—	18	—	—	9	6	3
Underlying or contributory	2.28	9	20	137	412	—	226	3	2	111	100	10
Other respiratory disease (470–475, 510–526, 527.0, 527.2)	1.47	—	—	9	33	—	13	—	—	7	5	1
Underlying or contributory	2.13	3	—	43	133	—	66	1	—	32	32	1
Total cardiovascular disease (330–334, 400–468)	1.87	128	470	1,263	2,854	—	1,933	40	42	974	825	52
Cerebral vascular lesions (330–334)	1.70	10	23	125	382	—	215	3	2	97	103	10
Underlying or contributory	1.75	15	33	195	616	—	350	4	3	153	170	20
Chronic rheumatic heart disease (410–416)	.91	—	7	29	23	—	21	—	1	15	4	1
Underlying or contributory	1.07	—	7	38	57	—	40	—	1	21	15	3
Arteriosclerotic (coronary) heart disease (420)	1.84	100	396	880	1,740	—	1,292	32	34	683	522	21
Underlying or contributory	1.92	110	442	1,018	2,277	—	1,552	35	38	793	659	27
Nonrheumatic endocarditis, etc. (421–422)	2.24	—	17	35	120	—	64	—	2	23	34	5
Underlying or contributory	2.18	—	30	69	290	—	133	—	3	53	72	5
Other heart disease (430–434)	2.00	—	7	26	57	—	38	—	1	19	16	2
Underlying or contributory	2.47	9	72	152	434	—	259	3	7	121	120	8
Hypertension with heart disease (440–443)	1.80	10	7	57	165	—	97	3	1	47	43	3
Underlying or contributory	1.70	13	22	170	375	—	249	4	3	133	102	7
Hypertension without heart disease (444–447)	1.78	4	—	16	39	—	22	1	—	10	10	1
Underlying or contributory	1.89	8	—	51	70	—	65	2	—	37	21	5
General arteriosclerosis (450)	2.02	—	13	33	147	—	72	—	1	29	36	6
Underlying or contributory	2.19	9	46	134	554	—	285	3	3	115	149	15
Nonsyphilitic aneurysm of aorta (451)	5.95	—	—	43	157	—	76	—	—	32	43	1
Other circulatory disease (400–402, 452–468)	2.13	4	—	23	52	—	36	1	—	19	14	2
Chronic nephritis, etc. (592–594)	1.73	—	7	7	16	—	14	—	1	5	7	1
Underlying or contributory	1.50	—	7	14	31	—	28	—	1	12	14	1
Diabetes mellitus (260)	1.11	5	—	8	8	—	10	1	—	7	2	—
Underlying or contributory	1.36	12	—	61	180	—	109	3	—	52	52	2
Paralysis agitans (350)	.08	—	—	—	2	—	1	—	—	—	1	—
Underlying or contributory	.20	—	—	—	18	—	5	—	—	—	5	—
Stomach ulcer (540)	5.45	—	—	9	36	—	15	—	—	8	7	—
Underlying or contributory	5.11	5	—	23	65	—	39	1	—	20	16	2
Duodenal ulcer (541)	3.98	—	7	5	65	—	22	—	1	4	15	2
Underlying or contributory	5.43	—	26	23	96	—	51	—	3	18	26	4
Cirrhosis of liver (581)	3.61	6	7	44	57	—	52	2	1	27	22	—
Other diseases of liver, etc. (580, 582–587)	2.19	3	—	8	25	—	17	1	—	8	8	—
Violence (800–962, 970–991)	1.32	65	116	91	101	—	134	21	10	71	31	1
Ill-defined and unknown (780–795, XXX)†	2.26	16	35	42	165	—	97	5	4	41	47	—
All other	1.80	3	7	48	278	—	100	1	1	42	56	—

See footnotes at end of Appendix table A.

781-871—65——5

Appendix table A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

	CURRENT SMOKERS OF CIGARETTES ONLY—OVER 39/DAY					
	Total 35–84	35–44	45–54	55–64	65–74	75–84
Person-years of observation:	24, 106	2, 819	1, 273	13, 958	5, 936	120

Cause of death (underlying cause unless otherwise specified, International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10⁵* 35–44	45–54	55–64	65–74	75–84	Number of deaths Total 35–84	35–44	45–54	55–64	65–74	75–84
All causes	2. 32	326	1, 160	2, 740	5, 591	—	699	10	14	406	258	11
Cancer, all sites (140–205)	3. 11	54	72	668	1, 273	—	171	2	1	100	66	2
Cancer of buccal cavity (140–144)	5. 73	—	—	9	9	—	3	—	—	2	1	—
Cancer of pharnyx (145–148)	19. 34	—	—	—	39	—	3	—	—	—	3	—
Cancer of esophagus (150)	7. 65	—	—	9	10	—	3	—	—	2	1	—
Cancer of stomach (151)	1. 87	—	—	53	46	—	8	—	—	6	2	—
Cancer of intestines (152–153)	1. 43	—	—	40	172	—	13	—	—	7	6	—
Cancer of rectum (154)	. 84	—	—	22	—	—	4	—	—	4	—	—
Cancer of pancreas (157)	1. 87	—	—	21	27	—	7	—	—	4	3	—
Cancer of larynx (161)	18. 85	—	—	20	—	—	3	—	—	3	—	—
Cancer of lung and bronchus (162–163)	23. 93	—	72	338	696	—	82	—	1	47	33	1
Cancer of prostate (177)	1. 95	—	—	32	24	—	8	—	—	6	2	—
Cancer of kidney (180)	2. 75	—	—	26	13	—	5	—	—	3	1	1
Cancer of bladder and other (181)	2. 52	—	—	20	45	—	5	—	—	3	2	—
Malignant lymphoma (200, 201, 203)	1. 20	—	—	36	10	—	7	—	—	6	1	—
Leukemia (204)	1. 45	54	—	8	20	—	5	2	—	1	2	—
All other sites (155–156, 158–160, 164–165, 170–176, 178–179, 190–199, 202, 205)	1. 34	—	—	35	171	—	15	—	—	6	9	—
Bronchitis and/or emphysema	18. 22	—	—	39	322	—	21	—	—	8	13	—
Bronchitis (500–502)	8. 31	—	—	5	46	—	4	—	—	1	3	—
Underlying or contributory	8. 73	—	—	37	78	—	11	—	—	5	6	—
Emphysema without bronchitis (527.1)	25. 34	—	—	34	276	—	17	—	—	7	10	—
Underlying or contributory	17. 37	—	—	95	616	—	46	—	—	17	27	2
Respiratory tuberculosis (001–008)	1. 65	—	—	5	—	—	1	—	—	1	—	—
Underlying or contributory	5. 61	—	—	35	125	—	8	—	—	6	2	—

Asthma (241)	5. 92	—	—	22	13	—	3	—	—	2	1	—
Underlying or contributory	4. 88	—	—	32	113	—	9	—	—	4	5	—
Influenza and pneumonia (480–493)	. 68	—	—	—	36	—	1	—	—	—	1	—
Underlying or contributory	2. 59	—	90	151	654	—	47	—	1	25	20	1
Other respiratory disease (470–475, 510–526, 527.0, 527.2)	3. 70	—	—	23	19	—	6	—	—	4	1	1
Underlying or contributory	3. 21	—	—	63	85	—	18	—	—	12	5	1
Total cardiovascular disease (330–334, 400–468)	2. 01	101	579	1, 621	3, 266	—	389	3	7	230	142	7
Cerebral vascular lesions (330–334)	1. 59	—	—	130	502	—	37	—	—	18	17	2
Underlying or contributory	1. 83	27	—	236	724	—	68	1	—	37	27	3
Chronic rheumatic heart disease (410–416)	1. 13	—	—	37	99	—	5	—	—	3	2	—
Underlying or contributory	1. 12	—	—	42	117	—	8	—	—	4	4	—
Arteriosclerotic (coronary) heart disease (420)	2. 00	101	508	1, 153	1, 891	—	266	3	6	165	87	5
Underlying or contributory	2. 11	101	508	1, 311	2, 392	—	320	3	6	192	114	5
Nonrheumatic endocarditis, etc. (421–422)	2. 05	—	—	62	93	—	11	—	—	7	4	—
Underlying or contributory	1. 85	—	—	110	158	—	21	—	—	13	8	—
Other heart disease (430–434)	1. 98	—	—	61	36	—	7	—	—	6	1	—
Underlying or contributory	2. 53	41	—	205	584	—	50	1	—	28	19	2
Hypertension with heart disease (440–443)	1. 67	—	72	59	107	—	17	—	1	11	5	—
Underlying or contributory	1. 81	—	72	241	356	—	50	—	1	34	15	—
Hypertension without heart disease (444–447)	1. 68	—	—	—	105	—	4	—	—	—	4	—
Underlying or contributory	2. 59	—	—	65	236	—	17	—	—	8	8	1
General arteriosclerosis (450)	2. 90	—	—	51	245	—	19	—	—	8	11	—
Underlying or contributory	2. 13	—	—	106	745	—	51	—	—	19	30	2
Nonsyphilitic aneurysm of aorta (451)	7. 26	—	—	44	221	—	17	—	—	7	10	—
Other circulatory disease (400–402, 452–468)	1. 96	—	—	32	10	—	6	—	—	5	1	—
Chronic nephritis, etc. (592–594)	3. 42	—	—	34	9	—	5	—	—	4	1	—
Underlying or contributory	2. 87	—	—	48	68	—	10	—	—	7	3	—
Diabetes mellitus (260)	1. 17	—	—	—	33	—	2	—	—	—	2	—
Underlying or contributory	1. 67	—	—	76	155	—	25	—	—	15	9	1
Paralysis agitans (350)	. 45	—	—	—	—	—	1	—	—	—	—	1
Underlying or contributory	. 66	—	—	4	—	—	3	—	—	1	—	2
Stomach ulcer (540)	11. 57	—	—	21	81	—	6	—	—	4	2	—
Underlying or contributory	6. 91	—	—	31	143	—	10	—	—	6	4	—
Duodenal ulcer (541)	2. 89	—	—	15	—	—	3	—	—	3	—	—
Underlying or contributory	3. 96	—	—	22	39	—	7	—	—	4	3	—
Cirrhosis of liver (581)	5. 50	—	162	46	87	—	15	—	2	8	5	—
Other diseases of liver, etc. (580, 582–587)	2. 04	—	—	10	10	—	3	—	—	2	1	—
Violence (800–962, 970–991)	1. 93	172	233	144	70	—	34	5	3	21	5	—
Ill-defined and unknown (780–795, XXX)†	3. 28	—	122	70	327	—	26	—	1	11	14	—
All other	1. 19	—	—	45	168	—	12	—	—	8	4	—

See footnotes at end of Appendix table A.

Appendix table A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

	CURRENT SMOKERS OF PIPES AND/OR CIGARS ONLY—TOTAL					
	Total 35–84	35–44	45–54	55–64	65–74	75–84
Person-years of observation:	195, 944	9, 269	5, 033	94, 172	82, 209	5, 260

Cause of death (underlying cause unless otherwise specified, International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10⁵ * 35–44	45–54	55–64	65–74	75–84	Number of deaths Total 35–84	35–44	45–54	55–64	65–74	75–84
All causes	1. 08	180	377	1, 100	2, 633	5, 782	3, 590	17	21	1, 257	2, 003	292
Cancer, all sites (140–205)	1. 25	8	102	226	537	1, 146	730	1	5	257	409	58
Cancer of buccal cavity (140–144)	3. 89	—	28	5	15	12	20	—	1	6	12	1
Cancer of pharynx (145–148)	3. 06	—	—	2	4	—	6	—	—	3	3	—
Cancer of esophagus (150)	4. 05	—	—	5	20	41	23	—	—	8	13	2
Cancer of stomach (151)	1. 21	—	—	15	40	114	55	—	—	17	32	6
Cancer of intestines (152–153)	1. 20	—	28	36	72	159	113	—	1	44	60	8
Cancer of rectum (154)	1. 07	—	—	16	29	33	48	—	—	23	23	2
Cancer of pancreas (157)	1. 13	—	26	19	38	32	48	—	1	17	28	2
Cancer of larynx (161)	7. 28	—	—	4	12	—	11	—	—	4	7	—
Cancer of lung and bronchus (162–163)	1. 67	—	10	22	47	53	62	—	1	22	35	4
Cancer of prostate (177)	1. 39	—	—	14	77	274	81	—	—	16	52	13
Cancer of kidney (180)	1. 15	—	—	5	14	40	21	—	—	9	10	2
Cancer of bladder and other (181)	1. 09	—	—	14	20	—	28	—	—	14	14	—
Malignant lymphoma (200, 201, 203)	. 82	—	—	6	39	70	47	—	—	10	33	4
Leukemia (204)	1. 16	8	—	22	26	—	41	1	—	18	22	—
All other sites (155–156, 158–160, 164–165, 170–176, 178–179, 190–199, 202, 205)	1. 13	—	10	43	85	325	126	—	1	46	65	14
Bronchitis and/or emphysema	. 99	11	—	1	20	12	15	1	—	2	11	1
Bronchitis (500–502)	. 48	11	—	—	4	—	3	1	—	—	2	—
Underlying or contributory	1. 17	11	—	6	15	51	19	1	—	6	10	2
Emphysema without bronchitis (527.1)	1. 34	—	—	1	16	12	12	—	—	2	9	1
Underlying or contributory	1. 31	—	10	7·	44	47	46	—	1	12	30	3
Respiratory tuberculosis (001–008)	. 39	—	—	1	2	—	3	—	—	1	2	—
Underlying or contributory	. 84	—	—	5	8	35	15	—	—	6	7	2

Asthma (241)	1. 22	—	—	1	4	—	5	—	—	2	3	—
Underlying or contributory	1. 09	11	—	5	9	57	20	1	—	8	8	3
Influenza and pneumonia (480–493)	. 79	—	10	2	13	56	16	—	1	4	8	3
Underlying or contributory	. 88	18	38	50	172	523	209	2	2	57	121	27
Other respiratory disease (470–475, 510–526, 527.0, 527.2)	. 69	—	—	5	12	23	14	—	—	5	8	1
Underlying or contributory	1. 05	—	—	29	58	89	72	—	—	27	41	4
Total cardiovascular disease (330–334, 400–468)	1. 05	67	144	676	1, 711	4, 051	2, 287	6	9	782	1, 290	200
Cerebral vascular lesions (330–334)	1. 06	25	—	90	238	835	321	3	—	103	174	41
Underlying or contributory	1. 05	25	—	132	374	1, 320	494	3	—	157	271	63
Chronic rheumatic heart disease (410–416)	. 74	—	—	6	28	44	31	—	—	9	20	2
Underlying or contributory	. 84	—	—	9	52	84	59	—	—	14	41	4
Arteriosclerotic (coronary) heart disease (420)	1. 05	42	124	455	1, 099	2, 206	1, 498	3	7	528	850	110
Underlying or contributory	1. 05	42	124	524	1, 300	2, 815	1, 747	3	7	607	991	139
Nonrheumatic endocarditis, etc. (421–422)	1. 19	—	—	20	65	273	76	—	—	18	45	13
Underlying or contributory	1. 17	—	26	49	122	473	158	—	1	47	88	22
Other heart disease (430–434)	. 94	—	—	10	37	103	41	—	—	11	26	4
Underlying or contributory	1. 13	—	28	66	198	513	252	—	1	83	145	23
Hypertension with heart disease (440–443)	. 99	—	10	37	71	173	106	—	1	45	52	8
Underlying or contributory	. 99	—	10	95	189	425	289	—	1	120	148	20
Hypertension without heart disease (444–447)	1. 20	—	—	10	20	72	28	—	—	10	14	4
Underlying or contributory	1. 35	—	—	36	58	200	90	—	—	37	43	10
General arteriosclerosis (450)	1. 00	—	—	18	99	333	100	—	—	22	64	14
Underlying or contributory	. 96	—	—	73	284	1, 038	325	—	—	80	197	48
Nonsyphilitic aneurysm of aorta (451)	1. 76	—	—	20	36	55	49	—	—	24	22	3
Other circulatory disease (400–402, 452–468)	1. 01	—	10	11	26	24	37	—	1	12	23	1
Chronic nephritis, etc. (592–594)	1. 18	—	—	7	9	44	18	—	—	10	6	2
Underlying or contributory	. 86	—	—	7	27	44	29	—	—	10	17	2
Diabetes mellitus (260)	1. 25	—	—	13	17	21	26	—	—	13	12	1
Underlying or contributory	1. 36	23	—	87	176	302	240	1	—	86	138	15
Paralysis agitans (350)	. 32	—	—	2	8	—	9	—	—	3	6	—
Underlying or contributory	. 37	—	—	3	27	21	22	—	—	5	16	1
Stomach ulcer (540)	2. 48	—	—	8	5	37	14	—	—	9	3	2
Underlying or contributory	1. 72	—	—	17	11	37	26	—	—	15	9	2
Duodenal ulcer (541)	1. 39	—	—	8	16	—	17	—	—	7	10	—
Underlying or contributory	1. 65	—	—	11	30	44	34	—	—	12	19	3
Cirrhosis of liver (581)	1. 82	—	—	19	33	21	48	—	—	20	27	1
Other diseases of liver, etc. (580, 582–587)	. 66	—	—	6	10	17	11	—	—	3	7	1
Violence (800–962, 970–991)	. 91	74	94	52	62	164	135	7	5	59	56	8
Ill-defined and unknown (780–795, XXX)†	1. 03	—	—	26	91	87	102	—	—	29	69	4
All other	1. 21	20	28	52	102	190	140	2	1	51	76	10

See footnotes at end of Appendix table A.

Appendix table A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

	CURRENT SMOKERS OF CIGARS ONLY—TOTAL					
	Total 35–84	35–44	45–54	55–64	65–74	75–84
Person-years of observation:	82,912	3,489	1,736	40,562	35,287	1,839

Cause of death (underlying cause unless otherwise specified, International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10⁵*					Number of deaths					
		35–44	45–54	55–64	65–74	75–84	Total 35–84	35–44	45–54	55–64	65–74	75–84
All causes	1. 10	176	471	1, 069	2, 594	6, 412	1, 532	5	10	535	867	115
Cancer, all sites (140–205)	1. 22	22	52	200	512	1, 388	301	1	2	104	169	25
Cancer of buccal cavity (140–144)	4. 11	—	—	3	18	33	9	—	—	2	6	1
Cancer of pharynx (145–148)	—	—	—	—	—	—	—	—	—	—	—	—
Cancer of esophagus (150)	5. 33	—	—	8	23	—	12	—	—	6	6	—
Cancer of stomach (151)	1. 20	—	—	9	46	212	23	—	—	5	14	4
Cancer of intestines (152–153)	1. 28	—	—	27	83	265	51	—	—	16	31	4
Cancer of rectum (154)	. 79	—	—	16	9	95	15	—	—	9	4	2
Cancer of pancreas (157)	1. 52	—	—	21	58	33	27	—	—	7	19	1
Cancer of larynx (161)	10. 33	—	—	3	20	—	6	—	—	2	4	—
Cancer of lung and bronchus (162–163)	1. 59	—	26	20	49	33	25	—	1	8	15	1
Cancer of prostate (177)	1. 50	—	—	12	73	354	36	—	—	9	21	6
Cancer of kidney (180)	. 77	—	—	7	2	—	6	—	—	5	1	—
Cancer of bladder and other (181)	. 94	—	—	18	9	—	10	—	—	6	4	—
Malignant lymphoma (200, 201, 203)	. 66	—	—	4	36	—	16	—	—	3	13	—
Leukemia (204)	1. 00	22	—	22	11	—	15	1	—	9	5	—
All other sites (155–156, 158–160, 164–165, 170–176, 178–179, 190–199, 202, 205)	1. 06	—	26	32	76	377	50	—	1	17	26	6
Bronchitis and/or emphysema	. 79	—	—	2	13	—	5	—	—	1	4	—
Bronchitis (500–502)	. 38	—	—	—	3	—	1	—	—	—	1	—
Underlying or contributory	1. 17	—	—	7	13	69	8	—	—	3	4	1
Emphysema without bronchitis (527.1)	1. 08	—	—	2	10	—	4	—	—	1	3	—
Underlying or contributory	1. 24	—	26	6	35	66	18	—	1	4	12	1
Respiratory tuberculosis (001–008)	. 31	—	—	1	—	—	1	—	—	1	—	—
Underlying or contributory	. 66	—	—	9	2	—	5	—	—	4	1	—

Asthma (241)	2.29	—	—	1	9	—	4	—	—	1	3	—
Underlying or contributory	1.67	—	—	5	16	165	13	—	—	4	6	3
Influenza and pneumonia (480–493)	.71	—	—	4	17	—	6	—	—	3	3	—
Underlying or contributory	.80	—	82	46	129	647	79	—	1	25	42	11
Other respiratory disease (470–475, 510–526, 527.0, 527.2)	.24	—	—	1	4	—	2	—	—	1	1	—
Underlying or contributory	.95	—	—	19	43	126	27	—	—	11	14	2
Total cardiovascular disease (330–334, 400–468)	1.05	84	238	662	1,658	4,389	960	2	5	327	549	77
Cerebral vascular lesions (330–334)	1.08	23	—	118	223	717	135	1	—	55	68	11
Underlying or contributory	1.02	23	—	152	342	1,177	200	1	—	74	107	18
Chronic rheumatic heart disease (410–416)	.56	—	—	4	16	—	10	—	—	3	7	—
Underlying or contributory	.73	—	—	8	34	33	22	—	—	6	15	1
Arteriosclerotic (coronary) heart disease (420)	1.04	61	212	410	1,070	2,559	623	1	4	206	366	46
Underlying or contributory	1.04	61	212	467	1,287	3,037	732	1	4	239	433	55
Nonrheumatic endocarditis, etc. (421–422)	1.43	—	—	18	65	357	38	—	—	11	21	6
Underlying or contributory	1.21	—	—	33	124	590	68	—	—	18	40	10
Other heart disease (430–434)	1.05	—	—	11	47	65	19	—	—	6	12	1
Underlying or contributory	1.15	—	79	56	232	707	108	—	1	30	66	11
Hypertension with heart disease (440–443)	1.17	—	26	43	89	341	53	—	1	18	28	6
Underlying or contributory	1.04	—	26	93	203	637	128	—	1	51	65	11
Hypertension without heart disease (444–447)	1.13	—	—	18	11	—	11	—	—	6	5	—
Underlying or contributory	1.45	—	—	60	47	342	41	—	—	20	16	5
General arteriosclerosis (450)	.97	—	—	9	96	261	39	—	—	6	29	4
Underlying or contributory	.98	—	—	99	272	877	136	—	—	40	82	14
Nonsyphilitic aneurysm of aorta (451)	2.06	—	—	17	43	156	24	—	—	11	10	3
Other circulatory disease (400–402, 452–468)	.52	—	—	15	6	—	8	—	—	5	3	—
Chronic nephritis, etc. (592–594)	1.58	—	—	11	4	128	10	—	—	7	1	2
Underlying or contributory	1.06	—	—	11	25	128	15	—	—	7	6	2
Diabetes mellitus (260)	1.88	—	—	28	12	63	16	—	—	11	4	1
Underlying or contributory	1.53	61	—	114	175	458	113	1	—	42	62	8
Paralysis agitans (350)	.25	—	—	2	4	—	3	—	—	1	2	—
Underlying or contributory	.36	—	—	3	23	63	9	—	—	2	6	1
Stomach ulcer (540)	2.90	—	—	13	3	33	7	—	—	5	1	1
Underlying or contributory	2.19	—	—	29	9	33	14	—	—	9	4	1
Duodenal ulcer (541)	1.58	—	—	9	25	—	8	—	—	3	5	—
Underlying or contributory	1.64	—	—	12	34	59	14	—	—	5	8	1
Cirrhosis of liver (581)	2.90	—	—	26	47	—	32	—	—	13	19	—
Other diseases of liver, etc. (580, 582–587)	.85	—	—	10	11	47	6	—	—	1	4	1
Violence (800–962, 970–991)	.91	70	101	44	78	59	57	2	2	21	31	1
Ill-defined and unknown (780–795, XXX)†	1.13	—	—	23	96	65	47	—	—	15	31	1
All other	1.39	—	82	37	120	344	67	—	1	20	40	6

See footnotes at end of Appendix table A.

Appendix table A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

	CURRENT SMOKERS OF PIPES ONLY—TOTAL					
	Total 35–84	35–44	45–54	55–64	65–74	75–84
Person-years of observation:	49, 545	3, 146	1, 552	22, 766	20, 558	1, 524

Cause of death (underlying cause unless otherwise specified, International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10⁵* 35–44	45–54	55–64	65–74	75–84	Number of deaths Total 35–84	35–44	45–54	55–64	65–74	75–84
All causes	1. 07	172	270	1, 144	2, 552	5, 642	895	6	4	318	485	82
Cancer, all sites (140–205)	1. 25	—	97	237	565	1, 001	184	—	1	59	110	14
Cancer of buccal cavity (140–144)	3. 12	—	97	2	11	—	4	—	1	1	2	—
Cancer of pharnyx (145–148)	1. 98	—	—	—	4	—	1	—	—	—	1	—
Cancer of esophagus (150)	1. 99	—	—	—	18	72	3	—	—	—	2	1
Cancer of stomach (151)	1. 40	—	—	21	57	—	16	—	—	4	12	—
Cancer of intestines (152–153)	. 98	—	—	35	58	—	23	—	—	10	13	—
Cancer of rectum (154)	. 90	—	—	8	29	—	10	—	—	3	7	—
Cancer of pancreas (157)	. 74	—	—	22	19	68	8	—	—	3	4	1
Cancer of larynx (161)	—	—	—	—	—	—	—	—	—	—	—	—
Cancer of lung and bronchus (162–163)	1. 84	—	—	24	54	—	17	—	—	7	10	—
Cancer of prostate (177)	1. 53	—	—	21	82	368	23	—	—	3	15	5
Cancer of kidney (180)	1. 32	—	—	2	25	—	6	—	—	1	5	—
Cancer of bladder and other (181)	1. 20	—	—	14	28	—	8	—	—	4	4	—
Malignant lymphoma (200, 201, 203)	. 91	—	—	10	28	170	13	—	—	4	6	3
Leukemia (204)	1. 58	—	—	14	56	—	14	—	—	4	10	—
All other sites (155–156, 158–160, 164–165, 170–176, 178–179, 190–199, 202, 205)	1. 36	—	—	64	98	327	38	—	—	15	19	4
Bronchitis and/or emphysema	2. 36	33	—	2	53	—	9	1	—	1	7	—
Bronchitis (500–502)	1. 28	33	—	—	9	—	2	1	—	—	1	—
Underlying or contributory	1. 70	33	—	2	27	86	7	1	—	1	4	1
Emphysema without bronchitis (527.1)	3. 11	—	—	2	44	—	7	—	—	1	6	—
Underlying or contributory	2. 13	—	—	12	76	43	19	—	—	5	13	1
Respiratory tuberculosis (001–008)	—	—	—	—	—	—	—	—	—	—	—	—
Underlying or contributory	. 67	—	—	—	11	79	3	—	—	—	2	1

Asthma (241)	.99	—	—	2	—	—	1	—	—	1	—	—
Underlying or contributory	1.10	33	—	7	4	—	5	1	—	3	1	—
Influenza and pneumonia (480–493)	.96	—	39	—	11	145	5	—	1	—	2	2
Underlying or contributory	.83	—	39	28	176	590	51	—	1	10	31	9
Other respiratory disease (470–475, 510–526, 527.0, 527.2)	1.69	—	—	19	25	80	9	—	—	4	4	1
Underlying or contributory	1.37	—	—	55	61	165	24	—	—	9	13	2
Total cardiovascular disease (330–334, 400–468)	1.06	25	134	694	1,639	4,126	582	1	2	209	311	59
Cerebral vascular lesions (330–334)	1.06	25	—	71	253	1,172	82	1	—	21	43	17
Underlying or contributory	1.09	25	—	124	408	1,715	132	1	—	35	71	25
Chronic rheumatic heart disease (410–416)	.87	—	—	11	32	—	9	—	—	3	6	—
Underlying or contributory	.97	—	—	11	68	—	17	—	—	3	14	—
Arteriosclerotic (coronary) heart disease (420)	1.08	—	134	524	1,005	1,849	386	—	2	155	203	26
Underlying or contributory	1.06	—	134	584	1,201	2,537	445	—	2	174	234	35
Nonrheumatic endocarditis, etc. (421–422)	1.30	—	—	13	91	226	21	—	—	4	14	3
Underlying or contributory	1.39	—	—	55	167	388	48	—	—	13	30	5
Other heart disease (430–434)	.98	—	—	2	41	154	11	—	—	1	8	2
Underlying or contributory	1.18	—	—	90	188	225	67	—	—	29	35	3
Hypertension with heart disease (440–443)	.82	—	—	27	70	—	22	—	—	9	13	—
Underlying or contributory	.94	—	—	81	195	235	69	—	—	27	39	3
Hypertension without heart disease (444–447)	1.37	—	—	6	13	247	8	—	—	2	2	4
Underlying or contributory	.71	—	—	9	27	247	12	—	—	3	5	4
General arteriosclerosis (450)	.99	—	—	25	91	482	26	—	—	8	12	6
Underlying or contributory	.96	—	—	63	250	1,432	85	—	—	21	44	20
Nonsyphilitic aneurysm of aorta (451)	1.13	—	—	11	25	—	8	—	—	4	4	—
Other circulatory disease (400–402, 452–468)	.96	—	—	6	27	85	9	—	—	2	6	1
Chronic nephritis, etc. (592–594)	.51	—	—	—	18	—	2	—	—	—	2	—
Underlying or contributory	.59	—	—	—	36	—	5	—	—	—	5	—
Diabetes mellitus (260)	.74	—	—	—	29	—	4	—	—	—	4	—
Underlying or contributory	.87	—	—	29	150	165	39	—	—	11	26	2
Paralysis agitans (350)	.41	—	—	2	10	—	3	—	—	1	2	—
Underlying or contributory	.52	—	—	5	34	—	8	—	—	2	6	—
Stomach ulcer (540)	2.84	—	—	7	9	—	4	—	—	3	1	—
Underlying or contributory	1.59	—	—	11	13	—	6	—	—	4	2	—
Duodenal ulcer (541)	1.59	—	—	14	8	—	5	—	—	3	2	—
Underlying or contributory	2.25	—	—	19	21	86	12	—	—	5	5	2
Cirrhosis of liver (581)	.60	—	—	—	20	—	4	—	—	—	4	—
Other diseases of liver, etc. (580, 582–587)	.23	—	—	2	—	—	1	—	—	1	—	—
Violence (800–962, 970–991)	.91	90	—	61	51	161	34	3	—	17	11	3
Ill-defined and unknown (780–795, XXX)†	.80	—	—	22	85	85	20	—	—	4	15	1
All other	.95	25	—	84	48	131	28	1	—	15	10	2

See footnotes at end of Appendix table A.

Appendix table A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

	CURRENT SMOKERS OF PIPES AND CIGARS ONLY—TOTAL					
	Total 35–84	35–44	45–54	55–64	65–74	75–84
Person-years of observation:	63,487	2,634	1,746	30,844	26,365	1,898

Cause of death (underlying cause unless otherwise specified, International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10⁵* 35–44	45–54	55–64	65–74	75–84	Number of deaths Total 35–84	35–44	45–54	55–64	65–74	75–84
All causes	1.08	195	376	1,107	2,730	5,223	1,163	6	7	404	651	95
Cancer, all sites (140–205)	1.28	—	148	249	548	1,037	245	—	2	94	130	19
Cancer of buccal cavity (140–144)	4.20	—	—	9	15	—	7	—	—	3	4	—
Cancer of pharynx (145–148)	7.76	—	—	6	9	—	5	—	—	3	2	—
Cancer of esophagus (150)	4.17	—	—	4	18	54	8	—	—	2	5	1
Cancer of stomach (151)	1.08	—	—	17	20	110	16	—	—	8	6	2
Cancer of intestines (152–153)	1.27	—	77	47	70	191	39	—	1	18	16	4
Cancer of rectum (154)	1.58	—	—	24	54	—	23	—	—	11	12	—
Cancer of pancreas (157)	.93	—	71	15	28	—	13	—	1	7	5	—
Cancer of larnyx (161)	9.44	—	—	9	12	—	5	—	—	2	3	—
Cancer of lung and bronchus (162–163)	1.66	—	—	22	39	117	20	—	—	7	10	3
Cancer of prostate (177)	1.15	—	—	9	79	115	22	—	—	4	16	2
Cancer of kidney (180)	1.52	—	—	6	20	112	9	—	—	3	4	2
Cancer of bladder and other (181)	1.18	—	—	10	26	—	10	—	—	4	6	—
Malignant lymphoma (200, 201, 203)	.96	—	—	6	54	55	18	—	—	3	14	1
Leukemia (204)	1.05	—	—	26	20	—	12	—	—	5	7	—
All other sites (155–156, 158–160, 164–165, 170–176, 178–179, 190–199, 202, 205)	1.05	—	—	40	87	286	38	—	—	14	20	4
Bronchitis and/or emphysema	.20	—	—	—	—	36	1	—	—	—	—	1
Bronchitis (500–502)	—	—	—	—	—	—	—	—	—	—	—	—
Underlying or contrubutory	.76	—	—	6	8	—	4	—	—	2	2	—
Emphysema without bronchitis (527.1)	.34	—	—	—	—	36	1	—	—	—	—	1
Underlying or contributory	.78	—	—	5	27	36	9	—	—	3	5	1
Respiratory tuberculosis (001–008)	.79	—	—	—	6	—	2	—	—	—	2	—
Underlying or contributory	1.21	—	—	4	11	36	7	—	—	2	4	1

Asthma (241)	—	—	—	—	—	—	—	—	—	—	—	—
Underlying or contributory	.33	—	—	2	3	—	2	—	—	1	1	—
Influenza and pneumonia (480–493)	.75	—	—	2	10	36	5	—	—	1	3	1
Underlying or contributory	1.01	63	—	71	223	363	79	2	—	22	48	7
Other respiratory disease (470–475, 510–526, 527.0, 527.2)	.44	—	—	—	12	—	3	—	—	—	3	—
Underlying or contributory	.93	—	—	22	77	—	21	—	—	7	14	—
Total cardiovascular disease (330–334, 400–468)	1.05	96	58	684	1,827	3,586	745	3	2	246	430	64
Cerebral vascular lesions (330–334)	1.05	29	—	70	244	668	104	1	—	27	63	13
Underlying or contributory	1.05	29	—	112	382	1,128	162	1	—	48	93	20
Chronic rheumatic heart disease (410–416)	.88	—	—	6	40	128	12	—	—	3	7	2
Underlying or contributory	.87	—	—	10	61	204	20	—	—	5	12	3
Arteriosclerotic (coronary) heart disease (420)	1.05	67	29	462	1,209	2,124	489	2	1	167	281	38
Underlying or contributory	1.05	67	29	553	1,389	2,773	570	2	1	194	324	49
Nonrheumatic endocarditis, etc. (421–422)	.81	—	—	26	41	225	17	—	—	3	10	4
Underlying or contributory	.95	—	71	65	81	416	42	—	1	16	18	7
Other heart disease (430–434)	.77	—	—	14	23	92	11	—	—	4	6	1
Underlying or contributory	1.05	—	—	62	166	556	77	—	—	24	44	9
Hypertension with heart disease (440–443)	.89	—	—	39	49	145	31	—	—	18	11	2
Underlying or contributory	.97	—	—	106	169	360	92	—	—	42	44	6
Hypertension without heart disease (444–447)	1.17	—	—	4	36	—	9	—	—	2	7	—
Underlying or contributory	1.69	—	—	29	97	36	37	—	—	14	22	1
General arteriosclerosis (450)	1.05	—	—	26	108	261	35	—	—	8	23	4
Underlying or contributory	.93	—	—	51	326	849	104	—	—	19	71	14
Nonsyphilitic aneurysm of aorta (451)	1.88	—	—	29	36	—	17	—	—	9	8	—
Other circulatory disease (400–402, 452–468)	1.65	—	29	10	51	—	20	—	1	5	14	—
Chronic nephritis, etc. (592–594)	1.19	—	—	6.	8	—	6	—	—	3	3	—
Underlying or contributory	.82	—	—	6	22	—	9	—	—	3	6	—
Diabetes mellitus (260)	.87	—	—	5	14	—	6	—	—	2	4	—
Underlying or contributory	1.52	—	—	99	194	261	88	—	—	33	50	5
Paralysis agitans (350)	.32	—	—	2	12	—	3	—	—	1	2	—
Underlying or contributory	.26	—	—	2	25	—	5	—	—	1	4	—
Stomach ulcer (540)	1.65	—	—	2	3	70	3	—	—	1	1	1
Underlying or contributory	1.22	—	—	6	12	70	6	—	—	2	3	1
Duodenal ulcer (541)	1.00	—	—	2	12	—	4	—	—	1	3	—
Underlying or contributory	1.18	—	—	3	35	—	8	—	—	2	6	—
Cirrhosis of liver (581)	1.38	—	—	24	24	55	12	—	—	7	4	1
Other diseases of liver, etc. (580, 582–587)	.73	—	—	5	16	—	4	—	—	1	3	—
Violence (800–962, 970–991)	.91	61	171	55	47	276	44	2	3	21	14	4
Ill-defined and unknown (780–795, XXX)†	1.09	—	—	30	87	109	35	—	—	10	23	2
All other	1.19	38	—	45	123	95	45	1	—	16	26	2

See footnotes at end of Appendix table A.

Appendix table A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

	EX-SMOKERS WHO STOPPED FOR REASONS OTHER THAN "DR'S. ORDERS"—TOTAL					
	Total 35–84	35–44	45–54	55–64	65–74	75–84
Person-years of observation:	335,592	26,103	11,794	164,446	126,371	6,878

Cause of death (underlying cause unless otherwise specified, International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10⁵*					Number of deaths					
		35–44	45–54	55–64	65–74	75–84	Total 35–84	35–44	45–54	55–64	65–74	75–84
All causes	1. 27	134	359	1, 328	3, 077	7, 013	6, 636	33	48	2, 532	3, 555	468
Cancer, all sites (140–205)	1. 43	20	108	286	605	1, 233	1, 330	6	14	528	700	82
Cancer of buccal cavity (140–144)	1. 93	—	—	3	10	20	16	—	—	5	10	1
Cancer of pharynx (145–148)	1. 65	4	—	—	3	—	5	1	—	—	4	—
Cancer of esophagus (150)	1. 55	—	—	2	6	—	13	—	—	5	8	—
Cancer of stomach (151)	1. 07	3	16	14	37	67	78	1	2	30	40	5
Cancer of intestines (152–153)	1. 21	—	17	42	72	113	182	—	3	77	93	9
Cancer of rectum (154)	1. 02	4	—	17	33	76	74	1	—	32	37	4
Cancer of pancreas (157)	1. 19	—	—	15	41	42	79	—	—	29	47	3
Cancer of larynx (161)	5. 81	—	—	4	5	51	14	—	—	7	5	2
Cancer of lung and bronchus (162–163)	4. 13	—	12	61	114	153	242	—	2	96	132	12
Cancer of prostate (177)	1. 61	—	—	22	67	231	142	—	—	47	78	17
Cancer of kidney (180)	1. 53	—	20	7	19	50	45	—	2	17	23	3
Cancer of bladder and other (181)	1. 54	—	5	6	38	98	61	—	1	16	38	6
Malignant lymphoma (200, 201, 203)	1. 03	—	10	33	43	12	95	—	1	45	48	1
Leukemia (204)	1. 54	3	5	14	42	116	87	1	1	32	46	7
All other sites (155–156, 158–160, 164–165, 170–176, 178–179, 190–199, 202, 205)	1. 09	6	23	47	77	212	197	2	2	90	91	12
Bronchitis and/or emphysema	6. 37	—	—	19	87	96	148	—	—	43	100	5
Bronchitis (500–502)	2. 48	—	—	3	15	21	24	—	—	6	17	1
Underlying or contributory	2. 21	—	—	5	34	144	56	—	—	12	37	7
Emphysema without bronchitis (527.1)	9. 15	—	—	16	71	76	124	—	—	37	83	4
Underlying or contributory	4. 87	—	—	33	161	272	260	—	—	70	174	16
Respiratory tuberculosis (001–008)	1. 42	—	—	7	4	37	17	—	—	7	7	3

Underlying or contributory	1. 70	—	—	15	16	61	47	—	—	22	20	5
Asthma (241)	2. 04	—	—	6	6	—	14	—	—	7	7	—
Underlying or contributory	2. 34	—	—	15	29	67	69	—	—	29	37	3
Influenza and pneumonia (480–493)	. 84	—	7	3	11	99	26	—	1	6	14	5
Underlying or contributory	1. 32	6	44	74	246	855	479	2	4	152	267	54
Other respiratory disease (470–475, 510–526, 527.0, 527.2)	1. 26	—	—	6	24	38	39	—	—	11	24	4
Underlying or contributory	1. 48	—	24	24	84	220	157	—	2	49	90	16
Total cardiovascular disease (330–334, 400–468)	1. 23	50	143	829	1, 953	4, 868	4, 194	11	20	1, 618	2, 226	319
Cerebral vascular lesions (330–334)	1. 09	7	26	63	257	1, 004	504	2	2	144	292	64
Underlying or contributory	1. 14	14	26	121	420	1, 532	829	4	2	262	467	94
Chronic rheumatic heart disease (410–416)	1. 24	8	11	20	35	74	84	1	2	39	37	5
Underlying or contributory	1. 33	8	22	28	77	101	152	1	3	56	85	7
Arteriosclerotic (coronary) heart disease (420)	1. 24	30	93	600	1, 266	2, 532	2, 790	7	14	1, 148	1, 452	169
Underlying or contributory	1. 25	30	121	671	1, 536	3, 247	3, 276	7	17	1, 292	1, 744	216
Nonrheumatic endocarditis, etc. (421–422)	1. 25	4	—	21	66	188	124	1	—	40	71	12
Underlying or contributory	1. 29	4	—	48	136	418	271	1	—	96	148	26
Other heart disease (430–434)	1. 33	—	5	14	41	35	89	—	1	32	53	3
Underlying or contributory	1. 59	6	34	101	278	628	555	1	5	201	310	38
Hypertension with heart disease (440–443)	1. 25	—	8	45	105	324	213	—	1	81	112	19
Underlying or contributory	1. 22	—	21	117	257	716	566	—	3	224	290	49
Hypertension without heart disease (444–447)	1. 10	—	—	13	14	42	41	—	—	22	16	3
Underlying or contributory	1. 15	—	—	34	42	148	123	—	—	65	49	9
General arteriosclerosis (450)	1. 15	—	—	21	95	535	170	—	—	44	98	28
Underlying or contributory	1. 17	4	—	82	313	1, 498	594	1	—	160	345	88
Nonsyphilitic aneurysm of aorta (451)	2. 51	—	—	13	58	168	109	—	—	32	65	12
Other circulatory disease (400–402, 452–468)	1. 22	—	—	20	27	55	70	—	—	36	30	4
Chronic nephritis, etc. (592–594)	1. 23	9	7	5	14	12	30	2	1	9	17	1
Underlying or contributory	1. 12	9	7	17	24	71	61	2	1	24	30	4
Diabetes mellitus (260)	. 63	—	—	4	10	—	20	—	—	7	13	—
Underlying or contributory	1. 10	—	5	47	165	297	302	—	1	99	181	21
Paralysis agitans (350)	. 68	—	—	3	24	18	30	—	—	3	26	1
Underlying or contributory	. 71	—	—	8	40	87	65	—	—	14	45	6
Stomach ulcer (540)	3. 23	4	—	2	23	30	29	1	—	4	22	2
Underlying or contributory	2. 65	4	6	9	42	116	64	1	1	14	42	6
Doudenal ulcer (541)	1. 90	—	5	7	15	25	36	—	1	15	18	2
Underlying or contributory	2. 10	—	5	12	29	83	67	—	1	27	34	5
Cirrhosis of liver (581)	1. 01	—	6	17	17	15	43	—	1	22	19	1
Other diseases of liver, etc. (580, 582–587)	1. 33	—	—	6	14	20	35	—	—	13	20	2
Violence (800–962, 970–991)	. 97	35	55	66	90	136	244	9	7	106	112	10
Ill-defined and unknown (780–795, XXX)†	1. 18	3	18	27	103	153	181	1	2	54	114	10
All other	1. 21	13	11	40	107	364	220	3	1	79	116	21

See footnotes at end of Appendix table A.

APPENDIX TABLE A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

EX-SMOKERS WHO STOPPED FOR REASONS OTHER THAN "DR'S. ORDERS"—EX-CIGARETTE SMOKERS—TOTAL

	Total 35–84	35–44	45–54	55–64	65–74	75–84
Person-years of observation:	281,855	24,456	10,721	139,390	102,246	5,044

Cause of death (underlying cause unless otherwise specified, International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10⁵*					Number of deaths					
		35–44	45–54	55–64	65–74	75–84	Total 35–84	35–44	45–54	55–64	65–74	75–84
All causes	1.27	129	319	1,340	3,126	7,184	5,431	30	39	2,131	2,887	344
Cancer, all sites (140–205)	1.49	17	86	302	647	1,344	1,137	5	10	465	593	64
Cancer of buccal cavity (140–144)	1.61	—	—	4	9	—	11	—	—	5	6	—
Cancer of pharynx (145–148)	1.63	4	—	—	2	—	4	1	—	—	3	—
Cancer of esophagus (150)	1.66	—	—	3	6	—	11	—	—	5	6	—
Cancer of stomach (151)	1.03	3	12	14	37	31	61	1	1	26	31	2
Cancer of intestines (152–153)	1.27	—	19	45	77	100	157	—	3	67	81	6
Cancer of rectum (154)	1.02	—	—	15	35	106	61	—	—	25	32	4
Cancer of pancreas (157)	1.32	—	—	17	45	57	71	—	—	26	42	3
Cancer of larynx (161)	7.22	—	—	4	7	74	14	—	—	7	5	2
Cancer of lung and bronchus (162–163)	4.71	—	13	71	128	184	226	—	2	94	119.	11
Cancer of prostate (177)	1.63	—	—	22	71	231	115	—	—	38	65	12
Cancer of kidney (180)	1.65	—	12	6	23	36	40	—	1	14	23	2
Cancer of bladder and other (181)	1.60	—	6	8	38	120	51	—	1	16	29	5
Malignant lymphoma (200, 201, 203)	1.10	—	11	35	45	16	84	—	1	42	40	1
Leukemia (204)	1.55	3	—	14	49	121	72	1	—	26	40	5
All other sites (155–156, 158–160, 164–165, 170–176, 178–179, 190–199, 202, 205)	1.07	7	13	45	77	276	159	2	1	74	71	11
Bronchitis and/or emphysema	7.64	—	—	21	108	97	143	—	—	40	99	4
Bronchitis (500–502)	3.06	—	—	3	19	29	24	—	—	6	17	1
Underlying or contributory	2.53	—	—	6	39	167	52	—	—	12	34	6
Emphysema without bronchitis (527.1)	10.96	—	—	18	89	69	119	—	—	34	82	3
Underlying or contributory	5.66	—	—	36	189	328	243	—	—	65	164	14
Respiratory tuberculosis (001–008)	1.24	—	—	3	3	51	12	—	—	5	4	3

Underlying or contributory	1.74	—	—	12	16	71	39	—	—	19	16	4
Asthma (241)	1.74	—	—	7	4	—	10	—	—	6	4	—
Underlying or contributory	2.48	—	—	16	32	57	60	—	—	25	33	2
Influenza and pneumonia (480–493)	.93	—	7	2	13	143	23	—	1	4	13	5
Underlying or contributory	1.37	6	22	76	252	1,002	402	2	2	135	219	44
Other respiratory disease (470–475, 510–526, 527.0, 527.2)	1.24	—	—	7	21	23	31	—	—	10	19	2
Underlying or contributory	1.48	—	11	25	82	212	127	—	1	41	74	11
Total cardiovascular disease (330–334, 400–468)	1.21	47	133	824	1,938	4,932	3,358	10	17	1,332	1,769	230
Cerebral vascular lesions (330–334)	1.07	8	14	62	250	1,179	400	2	1	118	226	53
Underlying or contributory	1.12	12	14	119	401	1,718	654	3	1	214	361	75
Chronic rheumatic heart disease (410–416)	1.10	8	12	20	28	71	62	1	2	32	24	3
Underlying or contributory	1.32	8	12	27	81	108	124	1	2	45	71	5
Arteriosclerotic (coronary) heart disease (420)	1.21	26	98	592	1,268	2,346	2,240	6	13	939	1,170	112
Underlying or contributory	1.22	26	128	663	1,528	3,175	2,626	6	16	1,062	1,392	150
Nonrheumatic endocarditis, etc. (421–422)	1.22	4	—	22	65	109	98	1	—	35	56	6
Underlying or contributory	1.25	4	—	46	137	316	212	1	—	78	117	16
Other heart disease (430–434)	1.31	—	—	15	39	36	71	—	—	28	41	2
Underlying or contributory	1.60	—	32	105	271	550	456	—	4	178	249	25
Hypertension with heart disease (440–443)	1.17	—	9	45	97	341	164	—	1	67	82	14
Underlying or contributory	1.16	—	23	112	250	659	440	—	3	178	225	34
Hypertension without heart disease (444–447)	1.11	—	—	13	17	16	34	—	—	19	14	1
Underlying or contributory	1.12	—	—	35	44	93	98	—	—	55	39	4
General arteriosclerosis (450)	1.16	—	—	20	93	672	136	—	—	35	76	25
Underlying or contributory	1.17	4	—	78	312	1,748	475	1	—	128	275	71
Nonsyphilitic aneurysm of aorta (451)	2.75	—	—	15	64	229	97	—	—	29	56	12
Other circulatory disease (400–402, 452–468)	1.21	—	—	21	29	34	56	—	—	30	24	2
Chronic nephritis, etc. (592–594)	1.26	10	7	5	13	16	25	2	1	8	13	1
Underlying or contributory	1.13	10	7	18	23	101	51	2	1	21	23	4
Diabetes mellitus (260)	.58	—	—	4	9	—	15	—	—	6	9	—
Underlying or contributory	1.07	—	6	44	158	317	238	—	1	80	141	16
Paralysis agitans (350)	.56	—	—	1	20	—	20	—	—	2	18	—
Underlying or contributory	.63	—	—	6	36	58	47	—	—	12	32	3
Stomach ulcer (540)	3.40	4	—	3	22	16	25	1	—	4	19	1
Underlying or contributory	2.93	4	6	10	47	112	58	1	1	13	39	4
Duodenal ulcer (541)	1.83	—	6	8	11	34	28	—	1	14	11	2
Underlying or contributory	2.10	—	6	13	27	119	54	—	1	23	25	5
Cirrhosis of liver (581)	1.02	—	—	16	20	20	36	—	—	18	17	1
Other diseases of liver, etc. (580, 582–587)	1.30	—	—	5	16	11	28	—	—	10	17	1
Violence (800–962, 970–991)	.95	38	61	67	92	103	200	9	7	88	90	6
Ill-defined and unknown (780–795, XXX)†	1.30	3	20	28	114	140	161	1	2	49	101	8
All other	1.20	10	—	41	106	398	179	2	—	70	91	16

See footnotes at end of Appendix table A.

Appendix table A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

	EX-SMOKERS WHO STOPPED FOR REASONS OTHER THAN "DR'S. ORDERS"—EX-CIGARETTE SMOKERS—1-9/DAY					
	Total 35–84	35–44	45–54	55–64	65–74	75–84
Person-years of observation:	53,003	2,758	1,525	25,221	21,978	1,520

Cause of death (underlying cause unless otherwise specified, International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10⁵*					Number of deaths					
		35–44	45–54	55–64	65–74	75–84	Total 35–84	35–44	45–54	55–64	65–74	75–84
All causes	1. 08	298	268	1, 054	2, 701	—	967	7	5	323	533	99
Cancer, all sites (140–205)	1. 18	29	36	174	532	—	186	1	1	62	112	10
Cancer of buccal cavity (140–144)	1. 46	—	—	—	13	—	2	—	—	—	2	—
Cancer of pharynx (145–148)	3. 75	—	—	—	8	—	2	—	—	—	2	—
Cancer of esophagus (150)	. 64	—	—	—	5	—	1	—	—	—	1	—
Cancer of stomach (151)	. 98	—	—	20	22	—	12	—	—	7	5	—
Cancer of intestines (152–153)	1. 11	—	36	22	85	—	28	—	1	8	17	2
Cancer of rectum (154)	. 91	—	—	12	39	—	11	—	—	4	7	—
Cancer of pancreas (157)	1. 22	—	—	8	53	—	14	—	—	2	12	—
Cancer of larynx (161)	4. 69	—	—	—	—	—	2	—	—	—	—	2
Cancer of lung and bronchus (162–163)	1. 41	—	—	11	30	—	14	—	—	5	7	2
Cancer of prostate (177)	1. 52	—	—	15	80	—	24	—	—	7	17	—
Cancer of kidney (180)	2. 04	—	—	10	28	—	10	—	—	4	6	—
Cancer of bladder and other (181)	1. 28	—	—	5	30	—	9	—	—	2	6	1
Malignant lymphoma (200, 201, 203)	. 84	—	—	20	29	—	13	—	—	7	6	—
Leukemia (204)	1. 58	—	—	28	36	—	15	—	—	6	9	—
All other sites (155–156, 158–160, 164–165, 170–176, 178–179, 190–199, 202, 205)	. 97	29	—	23	77	—	29	1	—	10	15	3
Bronchitis and/or emphysema	2. 20	—	—	9	17	—	9	—	—	4	4	1
Bronchitis (500–502)	. 60	—	—	—	4	—	1	—	—	—	1	—
Underlying or contributory	. 91	—	—	—	16	—	4	—	—	—	3	1
Emphysema without bronchitis (527.1)	3. 31	—	—	9	13	—	8	—	—	4	3	1
Underlying or contributory	1. 58	—	—	13	41	—	15	—	—	6	7	2
Respiratory tuberculosis (001–008)	. 95	—	—	—	3	—	2	—	—	—	1	1

Underlying or contributory	1. 66	—	—	5	27	—	8	—	—	2	5	1
Asthma (241)	. 91	—	—	—	3	—	1	—	—	—	1	—
Underlying or contributory	. 61	—	—	—	7	—	3	—	—	—	2	1
Influenza and pneumonia (480–493)	. 91	—	57	—	25	—	5	—	1	—	4	—
Underlying or contributory	1. 17	—	57	59	218	—	75	—	1	20	42	12
Other respiratory disease (470–475, 510–526, 527.0, 527.2)	. 72	—	—	4	3	—	4	—	—	2	1	1
Underlying or contributory	1. 24	—	—	17	63	—	23	—	—	7	13	3
Total cardiovascular disease (330–334, 400–468)	1. 05	146	176	681	1, 715	—	614	3	3	206	329	73
Cerebral vascular lesions (330–334)	. 89	—	—	66	197	—	73	—	—	19	35	19
Underlying or contributory	. 93	—	—	102	337	—	119	—	—	33	60	26
Chronic rheumatic heart disease (410–416)	1. 07	78	51	14	26	—	12	1	1	5	4	1
Underlying or contributory	1. 38	78	51	17	91	—	26	1	1	6	17	1
Arteriosclerotic (coronary) heart disease (420)	1. 02	32	125	432	1, 105	—	392	1	2	137	220	32
Underlying or contributory	1. 03	32	125	524	1, 360	—	464	1	2	160	262	39
Nonrheumatic endocarditis, etc. (421–422)	1. 45	37	—	43	51	—	25	1	—	9	11	4
Underlying or contributory	1. 17	37	—	63	98	—	43	1	—	16	19	7
Other heart disease (430–434)	1. 27	—	—	9	50	—	15	—	—	4	10	1
Underlying or contributory	1. 36	—	51	75	201	—	82	—	1	30	40	11
Hypertension with heart disease (440–443)	. 94	—	—	59	64	—	27	—	—	11	12	4
Underlying or contributory	1. 07	—	36	129	206	—	84	—	1	34	40	9
Hypertension without heart disease (444–447)	1. 11	—	—	6	14	—	7	—	—	3	3	1
Underlying or contributory	1. 11	—	—	36	41	—	20	—	—	10	8	2
General arteriosclerosis (450)	1. 39	—	—	26	143	—	38	—	—	6	23	9
Underlying or contributory	1. 28	—	—	107	367	—	118	—	—	24	67	27
Nonsyphilitic aneurysm of aorta (451)	1. 74	—	—	10	54	—	13	—	—	4	8	1
Other circulatory disease (400–402, 452–468)	1. 21	—	—	19	22	—	12	—	—	8	3	1
Chronic nephritis, etc. (592–594)	. 72	—	—	5	8	—	3	—	—	1	1	1
Underlying or contributory	. 77	—	—	21	8	—	7	—	—	3	1	3
Diabetes mellitus (260)	. 35	—	—	3	4	—	2	—	—	1	1	—
Underlying or contributory	1. 03	—	—	37	173	—	49	—	—	12	31	6
Paralysis agitans (350)	1. 03	—	—	—	44	—	8	—	—	—	8	—
Underlying or contributory	. 99	—	—	6	71	—	16	—	—	3	12	1
Stomach ulcer (540)	2. 65	37	—	—	25	—	4	1	—	—	3	—
Underlying or contributory	1. 97	37	—	—	57	—	8	1	—	—	7	—
Duodenal ulcer (541)	. 91	—	—	2	10	—	3	—	—	1	2	—
Underlying or contributory	1. 79	—	—	10	27	—	10	—	—	4	5	1
Cirrhosis of liver (581)	1. 12	—	—	20	15	—	8	—	—	4	4	—
Other diseases of liver, etc. (580, 582–587)	1. 55	—	—	10	14	—	7	—	—	3	4	—
Violence (800–962, 970–991)	1. 05	29	—	78	112	—	42	1	—	14	23	4
Ill-defined and unknown (780–795, XXX)†	1. 13	—	—	38	74	—	30	—	—	13	14	3
All other	1. 24	57	—	34	117	—	39	1	—	12	21	5

See footnotes at end of Appendix table A.

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Appendix table A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

	EX-SMOKERS WHO STOPPED FOR REASONS OTHER THAN "DR'S. ORDERS"—EX-CIGARETTE SMOKERS—10-20/DAY					
	Total 35–84	35–44	45–54	55–64	65–74	75–84
Person-years of observation:	134, 985	12, 163	5, 139	65, 770	49, 534	2, 380

Cause of death (underlying cause unless otherwise specified, International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10⁵*					Number of deaths					
		35–44	45–54	55–64	65–74	75–84	Total 35–84	35–44	45–54	55–64	65–74	75–84
All causes	1. 21	118	397	1, 228	3, 038	—	2, 465	14	22	928	1, 336	165
Cancer, all sites (140–205)	1. 41	20	81	259	644	—	514	3	4	200	270	37
Cancer of buccal cavity (140–144)	1. 22	—	—	4	8	—	4	—	—	2	2	—
Cancer of pharynx (145–148)	. 85	—	—	—	2	—	1	—	—	—	1	—
Cancer of esophagus (150)	. 95	—	—	1	3	—	3	—	—	1	2	—
Cancer of stomach (151)	. 84	7	—	9	40	—	24	1	—	8	13	2
Cancer of intestines (152–153)	1. 26	—	15	45	84	—	75	—	1	30	41	3
Cancer of rectum (154)	1. 01	—	—	12	31	—	29	—	—	13	15	1
Cancer of pancreas (157)	1. 12	—	—	14	35	—	29	—	—	13	14	2
Cancer of larynx (161)	6. 60	—	—	2	12	—	6	—	—	2	4	—
Cancer of lung and bronchus (162–163)	3. 47	—	—	49	109	—	80	—	—	32	43	5
Cancer of prostate (177)	1. 53	—	—	16	60	—	52	—	—	14	29	9
Cancer of kidney (180)	1. 73	—	—	7	28	—	20	—	—	7	12	1
Cancer of bladder and other (181)	1. 90	—	13	8	50	—	29	—	1	8	17	3
Malignant lymphoma (200, 201, 203)	1. 24	—	26	28	65	—	45	—	1	19	24	1
Leukemia (204)	1. 57	6	—	14	42	—	35	1	—	15	17	2
All other sites (155–156, 158–160, 164–165, 170–176, 178–179, 190–199, 202, 205)	1. 15	6	28	51	80	—	82	1	1	36	36	8
Bronchitis and/or emphysema	8. 33	—	—	16	125	—	75	—	—	18	55	2
Bronchitis (500–502)	2. 11	—	—	1	15	—	8	—	—	1	6	1
Underlying or contributory	2. 11	—	—	3	32	—	21	—	—	3	14	4
Emphysema without bronchitis (527.1)	12. 86	—	—	15	111	—	67	—	—	17	49	1
Underlying or contributory	5. 78	—	—	23	195	—	119	—	—	26	83	10
Respiratory tuberculosis (001–008)	1. 07	—	—	4	3	—	5	—	—	2	2	1

Underlying or contributory	1. 20	—	—	9	10	—	13	—	—	7	5	1
Asthma (241)	1. 10	—	—	2	2	—	3	—	—	2	1	—
Underlying or contributory	2. 51	—	—	11	35	—	29	—	—	11	17	1
Influenza and pneumonia (480–493)	. 84	—	—	2	12	—	10	—	—	2	7	1
Underlying or contributory	1. 33	13	31	79	248	—	187	2	1	64	100	20
Other respiratory disease (470–475, 510–526, 527.0, 527.2)	1. 18	—	—	4	25	—	14	—	—	3	11	—
Underlying or contributory	1. 34	—	26	21	83	—	55	—	1	15	35	4
Total cardiovascular disease (330–334, 400–468)	1. 15	31	195	774	1, 885	—	1, 528	3	11	578	824	112
Cerebral vascular lesions (330–334)	1. 01	—	31	53	238	—	181	—	1	49	104	27
Underlying or contributory	1. 03	—	31	109	372	—	289	—	1	89	163	36
Chronic rheumatic heart disease (410–416)	1. 16	—	13	17	33	—	31	—	1	14	14	2
Underlying or contributory	1. 34	—	13	25	86	—	60	—	1	22	34	3
Arteriosclerotic (coronary) heart disease (420)	1. 16	31	133	557	1, 260	—	1, 030	3	8	410	554	55
Underlying or contributory	1. 15	31	174	624	1, 471	—	1, 186	3	10	464	638	71
Nonrheumatic endocarditis, etc. (421–422)	1. 12	—	—	21	63	—	43	—	—	16	25	2
Underlying or contributory	1. 23	—	—	45	152	—	100	—	—	34	58	8
Other heart disease (430–434)	1. 16	—	—	11	33	—	30	—	—	11	18	1
Underlying or contributory	1. 52	—	44	89	272	—	207	—	2	72	122	11
Hypertension with heart disease (440–443)	1. 18	—	18	47	99	—	79	—	1	32	40	6
Underlying or contributory	1. 10	—	36	97	245	—	200	—	2	77	105	16
Hypertension without heart disease (444–447)	1. 37	—	—	17	26	—	20	—	—	10	10	—
Underlying or contributory	1. 24	—	—	38	61	—	52	—	—	25	25	2
General arteriosclerosis (450)	. 80	—	—	16	51	—	45	—	—	13	20	12
Underlying or contributory	. 99	—	—	56	260	—	192	—	—	50	111	31
Nonsyphilitic aneurysm of aorta (451)	2. 83	—	—	16	65	—	48	—	—	15	27	6
Other circulatory disease (400–402, 452–468)	. 94	—	—	20	29	—	21	—	—	8	12	1
Chronic nephritis, etc. (592–594)	1. 05	20	—	4	10	—	10	2	—	2	6	—
Underlying or contributory	. 98	20	—	21	21	—	21	2	—	8	10	1
Diabetes mellitus (260)	. 33	—	—	3	3	—	4	—	—	2	2	—
Underlying or contributory	. 87	—	—	46	111	—	93	—	—	35	52	6
Paralysis agitans (350)	. 70	—	—	2	21	—	12	—	—	2	10	—
Underlying or contributory	. 70	—	—	9	35	—	25	—	—	7	17	1
Stomach ulcer (540)	2. 55	—	—	4	14	—	9	—	—	3	6	—
Underlying or contributory	3. 17	—	13	19	34	—	30	—	1	10	16	3
Duodenal ulcer (541)	2. 46	—	13	10	19	—	18	—	1	7	9	1
Underlying or contributory	2. 61	—	13	17	35	—	32	—	1	12	16	3
Cirrhosis of liver (581)	. 66	—	—	9	17	—	11	—	—	5	5	1
Other diseases of liver, etc. (580, 582–587)	1. 26	—	—	3	19	—	13	—	—	3	9	1
Violence (800–962, 970–991)	. 86	41	96	59	67	—	87	5	5	43	33	1
Ill-defined and unknown (780–795, XXX)†	1. 17	6	13	23	105	—	70	1	1	20	45	3
All other	1. 15	—	—	53	97	—	82	—	—	36	41	5

See footnotes at end of Appendix table A.

APPENDIX TABLE A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

	EX-SMOKERS WHO STOPPED FOR REASONS OTHER THAN "DR'S. ORDERS"—EX-CIGARETTE SMOKERS—21–39/DAY					
	Total 35–84	35–44	45–54	55–64	65–74	75–84
Person-years of observation:	70,087	7,791	3,132	35,929	22,417	818

Cause of death (underlying cause unless otherwise specified, International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10⁵* 35–44	45–54	55–64	65–74	75–84	Number of deaths Total 35–84	35–44	45–54	55–64	65–74	75–84
All causes	1. 47	87	285	1, 621	3, 469	—	1, 440	7	11	645	713	64
Cancer, all sites (140–205)	1. 76	12	106	403	715	—	309	1	4	145	147	12
Cancer of buccal cavity (140–144)	3. 11	—	—	7	10	—	5	—	—	3	2	—
Cancer of pharynx (145–148)	1. 84	12	—	—	—	—	1	1	—	—	—	—
Cancer of esophagus (150)	4. 27	—	—	6	14	—	6	—	—	3	3	—
Cancer of stomach (151)	1. 09	—	—	15	30	—	15	—	—	7	8	—
Cancer of intestines (152–153)	1. 28	—	19	58	47	—	37	—	1	22	13	1
Cancer of rectum (154)	1. 05	—	—	24	28	—	15	—	—	7	5	3
Cancer of pancreas (157)	1. 72	—	—	20	43	—	21	—	—	8	12	1
Cancer of larynx (161)	11. 28	—	—	12	3	—	5	—	—	4	1	—
Cancer of lung and bronchus (162–163)	8. 34	—	45	138	208	—	92	—	2	42	45	3
Cancer of prostate (177)	2. 04	—	—	32	106	—	31	—	—	13	17	1
Cancer of kidney (180)	1. 06	—	42	2	9	—	6	—	1	1	3	1
Cancer of bladder and other (181)	1. 44	—	—	10	23	—	10	—	—	5	5	—
Malignant lymphoma (200, 201, 203)	. 90	—	—	25	26	—	16	—	—	8	8	—
Leukemia (204)	1. 48	—	—	5	89	—	16	—	—	3	11	2
All other sites (155–156, 158–160, 164–165, 170–176, 178–179, 190–199, 202, 205)	. 94	—	—	49	79	—	33	—	—	19	14	—
Bronchitis and/or emphysema	10. 49	—	—	46	134	—	43	—	—	18	24	1
Bronchitis (500–502)	5. 14	—	—	12	28	—	9	—	—	5	4	—
Underlying or contributory	3. 51	—	—	16	53	—	16	—	—	7	8	1
Emphysema without bronchitis (527.1)	14. 46	—	—	35	106	—	34	—	—	13	20	1
Underlying or contributory	8. 76	—	—	82	284	—	82	—	—	31	49	2
Respiratory tuberculosis (001–008)	2. 34	—	—	5	4	—	5	—	—	3	1	1

Underlying or contributory	3. 40	—	—	26	18	—	17	—	—	10	5	2
Asthma (241)	4. 25	—	—	20	11	—	6	—	—	4	2	—
Underlying or contributory	3. 88	—	—	36	47	—	22	—	—	12	10	—
Influenza and pneumonia (480–493)	. 56	—	—	—	5	—	3	—	—	—	1	2
Underlying or contributory	1. 49	—	—	79	275	—	96	—	—	37	51	8
Other respiratory disease (470–475, 510–526, 527.0, 527.2)	2. 01	—	—	8	40	—	11	—	—	3	7	1
Underlying or contributory	1. 78	—	—	18	94	—	34	—	—	9	21	4
Total cardiovascular disease (330–334, 400–468)	1. 40	32	57	960	2, 096	—	886	3	3	408	434	38
Cerebral vascular lesions (330–334)	1. 18	10	—	67	273	—	97	1	—	35	54	7
Underlying or contributory	1. 26	25	—	124	464	—	163	2	—	60	90	11
Chronic rheumatic heart disease (410–416)	1. 20	—	—	20	28	—	16	—	—	10	6	—
Underlying or contributory	1. 27	—	—	28	54	—	28	—	—	14	14	—
Arteriosclerotic (coronary) heart disease (420)	1. 43	22	57	743	1, 366	—	610	2	3	301	285	19
Underlying or contributory	1. 46	22	57	813	1, 689	—	720	2	3	335	348	32
Nonrheumatic endocarditis, etc. (421–422)	1. 28	—	—	14	83	—	23	—	—	7	16	—
Underlying or contributory	1. 29	—	—	36	143	—	49	—	—	18	30	1
Other heart disease (430–434)	1. 33	—	—	21	25	—	16	—	—	9	7	—
Underlying or contributory	1. 83	—	19	148	322	—	118	—	1	57	58	2
Hypertension with heart disease (440–443)	1. 30	—	—	32	127	—	42	—	—	16	22	4
Underlying or contributory	1. 32	—	—	128	311	—	116	—	—	48	59	9
Hypertension without heart disease (444–447)	. 70	—	—	7	3	—	5	—	—	4	1	—
Underlying or contributory	. 84	—	—	30	10	—	17	—	—	14	3	—
General arteriosclerosis (450)	1. 46	—	—	22	104	—	36	—	—	11	21	4
Underlying or contributory	1. 33	12	—	103	299	—	116	1	—	45	61	9
Nonsyphilitic aneurysm of aorta (451)	3. 40	—	—	13	74	—	27	—	—	6	17	4
Other circulatory disease (400–402, 452–468)	1. 35	—	—	24	25	—	14	—	—	9	5	—
Chronic nephritis, etc. (592–594)	2. 39	—	26	9	30	—	11	—	1	4	6	—
Underlying or contributory	1. 70	—	26	15	39	—	18	—	1	8	9	—
Diabetes mellitus (260)	1. 05	—	—	5	16	—	6	—	—	2	4	—
Underlying or contributory	1. 34	—	19	49	198	—	67	—	1	24	40	2
Paralysis agitans (350)	—	—	—	—	—	—	—	—	—	—	—	—
Underlying or contributory	. 25	—	—	2	7	—	4	—	—	1	2	1
Stomach ulcer (540)	4. 12	—	—	2	19	—	7	—	—	1	5	1
Underlying or contributory	3. 27	—	—	6	54	—	15	—	—	3	11	1
Duodenal ulcer (541)	1. 17	—	—	9	—	—	4	—	—	4	—	—
Underlying or contributory	1. 39	—	—	10	14	—	8	—	—	5	3	—
Cirrhosis of liver (581)	1. 45	—	—	30	28	—	12	—	—	8	4	—
Other diseases of liver, etc. (580, 582–587)	1. 02	—	—	8	3	—	5	—	—	4	1	—
Violence (800–962, 970–991)	1. 01	27	50	73	140	—	52	2	2	19	28	1
Ill-defined and unknown (780–795, XXX)†	1. 63	—	48	29	169	—	45	—	1	10	32	2
All other	1. 04	15	—	22	96	—	35	1	—	12	17	5

See footnotes at end of Appendix table A.

Appendix table A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

EX-SMOKERS WHO STOPPED FOR REASONS OTHER THAN "DR'S. ORDERS"—EX-CIGARETTE SMOKERS—OVER 39/DAY

	Total 35–84	35–44	45–54	55–64	65–74	75–84
Person-years of observation:	23,780	1,743	925	12,470	8,317	325

Cause of death (underlying cause unless otherwise specified, International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10⁵*					Number of deaths					
		35–44	45–54	55–64	65–74	75–84	Total 35–84	35–44	45–54	55–64	65–74	75–84
All causes	1. 58	146	137	1, 630	3, 883	—	559	2	1	235	305	16
Cancer, all sites (140–205)	2. 03	—	137	446	803	—	128	—	1	58	64	5
Cancer of buccal cavity (140–144)	—	—	—	—	—	—	—	—	—	—	—	—
Cancer of pharynx (145–148)	—	—	—	—	—	—	—	—	—	—	—	—
Cancer of esophagus (150)	1. 87	—	—	5	—	—	1	—	—	1	—	—
Cancer of stomach (151)	2. 03	—	137	26	83	—	10	—	1	4	5	—
Cancer of intestines (152–153)	1. 65	—	—	50	85	—	17	—	—	7	10	—
Cancer of rectum (154)	1. 18	—	—	5	61	—	6	—	—	1	5	—
Cancer of pancreas (157)	1. 56	—	—	38	91	—	7	—	—	3	4	—
Cancer of larynx (161)	6. 16	—	—	5	—	—	1	—	—	1	—	—
Cancer of lung and bronchus (162–163)	10. 05	—	—	90	300	—	40	—	—	15	24	1
Cancer of prostate (177)	1. 43	—	—	31	30	—	8	—	—	4	2	2
Cancer of kidney (180)	1. 96	—	—	9	16	—	4	—	—	2	2	—
Cancer of bladder and other (181)	1. 18	—	—	5	24	—	3	—	—	1	1	1
Malignant lymphoma (200, 201, 203)	1. 57	—	—	125	17	—	10	—	—	8	2	—
Leukemia (204)	1. 55	—	—	10	38	—	6	—	—	2	3	1
All other sites (155–156, 158–160, 164–165, 170–176, 178–179, 190–199, 202, 205)	1. 21	—	—	49	60	—	15	—	—	9	6	—
Bronchitis and/or emphysema	10. 57	—	—	—	196	—	16	—	—	—	16	—
Bronchitis (500–502)	9. 41	—	—	—	69	—	6	—	—	—	6	—
Underlying or contributory	6. 63	—	—	10	120	—	11	—	—	2	9	—
Emphysema without bronchitis (527.1)	11. 41	—	—	—	127	—	10	—	—	—	10	—
Underlying or contributory	7. 77	—	—	9	329	—	27	—	—	2	25	—
Respiratory tuberculosis (001–008)	—	—	—	—	—	—	—	—	—	—	—	—

Underlying or contributory	.55	—	—	—	12	—	1	—	—	—	1	—
Asthma (241)	—	—	—	—	—	—	—	—	—	—	—	—
Underlying or contributory	2.93	—	—	10	47	—	6	—	—	2	4	—
Influenza and pneumonia (480–493)	2.53	—	—	15	8	—	5	—	—	2	1	2
Underlying or contributory	1.86	—	—	87	303	—	44	—	—	14	26	4
Other respiratory disease (470–475, 510–526, 527.0, 527.2)	.99	—	—	21	—	—	2	—	—	2	—	—
Underlying or contributory	2.14	—	—	78	96	—	15	—	—	10	5	—
Total cardiovascular disease (330–334, 400–468)	1.44	63	—	974	2,402	—	330	1	—	140	182	7
Cerebral vascular lesions (330–334)	1.63	63	—	94	393	—	49	1	—	15	33	—
Underlying or contributory	1.75	63	—	200	578	—	83	1	—	32	48	2
Chronic rheumatic heart disease (410–416)	.63	—	—	48	—	—	3	—	—	3	—	—
Underlying or contributory	1.26	—	—	48	79	—	10	—	—	3	6	1
Arteriosclerotic (coronary) heart disease (420)	1.35	—	—	646	1,482	—	208	—	—	91	111	6
Underlying or contributory	1.44	—	137	709	1,876	—	256	—	1	103	144	8
Nonrheumatic endocarditis, etc. (421–422)	1.06	—	—	16	79	—	7	—	—	3	4	—
Underlying or contributory	1.44	—	—	51	128	—	20	—	—	10	10	—
Other heart disease (430–434)	2.27	—	—	30	89	—	10	—	—	4	6	—
Underlying or contributory	2.08	—	—	109	333	—	49	—	—	19	29	1
Hypertension with heart disease (440–443)	1.38	—	—	49	104	—	16	—	—	8	8	—
Underlying or contributory	1.26	—	—	110	240	—	40	—	—	19	21	—
Hypertension without heart disease (444–447)	.78	—	—	17	—	—	2	—	—	2	—	—
Underlying or contributory	1.22	—	—	36	38	—	9	—	—	6	3	—
General arteriosclerosis (450)	1.84	—	—	31	159	—	17	—	—	5	12	—
Underlying or contributory	1.51	—	—	61	489	—	49	—	—	9	36	4
Nonsyphilitic aneurysm of aorta (451)	3.09	—	—	19	58	—	9	—	—	4	4	1
Other circulatory disease (400–402, 452–468)	2.38	—	—	27	56	—	9	—	—	5	4	—
Chronic nephritis, etc. (592–594)	.61	—	—	5	—	—	1	—	—	1	—	—
Underlying or contributory	1.32	—	—	10	25	—	5	—	—	2	3	—
Diabetes mellitus (260)	1.42	—	—	5	44	—	3	—	—	1	2	—
Underlying or contributory	1.58	—	—	43	302	—	29	—	—	9	18	2
Paralysis agitans (350)	—	—	—	—	—	—	—	—	—	—	—	—
Underlying or contributory	.34	—	—	5	9	—	2	—	—	1	1	—
Stomach ulcer (540)	8.14	—	—	—	63	—	5	—	—	—	5	—
Underlying or contributory	3.01	—	—	—	63	—	5	—	—	—	5	—
Duodenal ulcer (541)	2.34	—	—	9	—	—	3	—	—	2	—	1
Underlying or contributory	1.85	—	—	9	8	—	4	—	—	2	1	1
Cirrhosis of liver (581)	1.68	—	—	5	32	—	5	—	—	1	4	—
Other diseases of liver, etc. (580, 582–587)	1.69	—	—	—	30	—	3	—	—	—	3	—
Violence (800–962, 970–991)	1.07	82	—	71	52	—	19	1	—	12	6	—
Ill-defined and unknown (780–795, XXX)†	1.59	—	—	34	144	—	16	—	—	6	10	—
All other	1.89	—	—	54	153	—	23	—	—	10	12	1

See footnotes at end of Appendix table A.

Appendix table A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

EX-SMOKERS WHO STOPPED FOR REASONS OTHER THAN "DR'S. ORDERS"—EX-SMOKERS OF CIGARETTES ONLY—TOTAL

	Total 35–84	35–44	45–54	55–64	65–74	75–84
Person-years of observation:	144,681	14,680	6,032	71,392	50,342	2,235

Cause of death (underlying cause unless otherwise specified, International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10⁵*					Number of deaths					
		35–44	45–54	55–64	65–74	75–84	Total 35–84	35–44	45–54	55–64	65–74	75–84
All causes	1. 35	83	365	1, 451	3, 333	—	2, 861	13	24	1, 170	1, 508	146
Cancer, all sites (140–205)	1. 44	6	112	303	663	—	544	1	7	228	282	26
Cancer of buccal cavity (140–144)	2. 05	—	—	7	8	—	7	—	—	5	2	—
Cancer of pharynx (145–148)	. 83	—	—	—	2	—	1	—	—	—	1	—
Cancer of esophagus (150)	1. 57	—	—	2	7	—	5	—	—	2	3	—
Cancer of stomach (151)	. 88	6	—	14	33	—	26	1	—	14	10	1
Cancer of intestines (152–153)	1. 15	—	35	34	86	—	71	—	3	25	42	1
Cancer of rectum (154)	. 86	—	—	14	35	—	26	—	—	11	13	2
Cancer of pancreas (157)	1. 17	—	—	18	41	—	31	—	—	14	16	1
Cancer of larynx (161)	10. 53	—	—	5	14	—	10	—	—	4	5	1
Cancer of lung and bronchus (162–163)	5. 00	—	11	83	135	—	119	—	1	53	60	5
Cancer of prostate (177)	1. 51	—	—	17	73	—	52	—	—	16	32	4
Cancer of kidney (180)	1. 74	—	21	6	23	—	21	—	1	7	11	2
Cancer of bladder and other (181)	1. 55	—	—	8	44	—	24	—	—	9	14	1
Malignant lymphoma (200, 201, 203)	1. 13	—	22	42	48	—	43	—	1	22	19	1
Leukemia (204)	1. 42	—	—	13	51	—	33	—	—	11	20	2
All other sites (155–156, 158–160, 164–165, 170–176, 178–179, 190–199, 202, 205)	1. 01	—	24	39	64	—	75	—	1	35	34	5
Bronchitis and/or emphysema	10. 23	—	—	32	133	—	94	—	—	30	63	1
Bronchitis (500–502)	4. 90	—	—	7	25	—	19	—	—	6	13	—
Underlying or contributory	3. 35	—	—	12	40	—	34	—	—	12	20	2
Emphysema without bronchitis (527.1)	14. 12	—	—	26	108	—	75	—	—	24	50	1
Underlying or contributory	6. 91	—	—	50	229	—	145	—	—	43	97	5
Respiratory tuberculosis (001–008)	1. 26	—	—	3	3	—	6	—	—	3	2	1

Underlying or contributory	1. 90	—	—	10	14	—	21	—	—	10	9	2
Asthma (241)	2. 42	—	—	11	5	—	7	—	—	5	2	—
Underlying or contributory	3. 31	—	—	25	44	—	40	—	—	19	21	—
Influenza and pneumonia (480–493)	. 83	—	13	4	11	—	10	—	1	3	6	—
Underlying or contributory	1. 46	—	39	79	284	—	210	—	2	73	117	18
Other respiratory disease (470–475, 510–526, 527.0, 527.2)	1. 40	—	—	9	27	—	7	—	—	7	10	—
Underlying or contributory	1. 59	—	22	25	94	—	67	—	1	23	40	3
Total cardiovascular disease (330–334, 400–468)	1. 30	31	133	884	2, 058	—	1, 794	5	9	740	935	105
Cerebral vascular lesions (330–334)	1. 15	5	26	71	252	—	209	1	1	69	115	23
Underlying or contributory	1. 22	13	26	124	431	—	349	2	1	118	192	36
Chronic rheumatic heart disease (410–416)	1. 10	—	—	17	35	—	31	—	—	17	14	—
Underlying or contributory	1. 41	—	—	26	93	—	66	—	—	24	41	1
Arteriosclerotic (coronary) heart disease (420)	1. 30	18	92	636	1, 342	—	1, 192	3	7	517	615	50
Underlying or contributory	1. 30	18	116	715	1, 604	—	1, 383	3	8	585	724	63
Nonrheumatic endocarditis, etc. (421–422)	1. 22	8	—	20	65	—	48	1	—	18	26	3
Underlying or contributory	1. 36	8	—	51	136	—	113	1	—	47	60	5
Other heart disease (430–434)	1. 70	—	—	17	57	—	45	—	—	16	27	2
Underlying or contributory	1. 85	—	33	121	315	—	260	—	2	106	142	10
Hypertension with heart disease (440–443)	1. 35	—	15	57	115	—	94	—	1	39	49	5
Underlying or contributory	1. 30	—	15	141	268	—	245	—	1	108	121	15
Hypertension without heart disease (444–447)	1. 44	—	—	11	25	—	22	—	—	12	9	1
Underlying or contributory	1. 33	—	—	35	56	—	58	—	—	32	24	2
General arteriosclerosis (450)	1. 15	—	—	12	83	—	65	—	—	14	37	14
Underlying or contributory	1. 26	—	—	84	309	—	249	—	—	70	141	38
Nonsyphilitic aneurysm of aorta (451)	3. 04	—	—	18	71	—	53	—	—	17	30	6
Other circulatory disease (400–402, 452–468)	1. 53	—	—	26	26	—	35	—	—	21	13	1
Chronic nephritis, etc. (592–594)	1. 61	6	—	9	16	—	16	1	—	7	8	—
Underlying or contributory	1. 47	6	—	19	27	—	33	1	—	15	15	2
Diabetes mellitus (260)	. 56	—	—	3	10	—	7	—	—	3	4	—
Underlying or contributory	1. 08	—	11	49	144	—	119	—	1	45	66	7
Paralysis agitans (350)	. 69	—	—	2	26	—	12	—	—	2	10	—
Underlying or contributory	. 72	—	—	6	49	—	26	—	—	6	19	1
Stomach ulcer (540)	2. 74	—	—	4	20	—	10	—	—	3	7	—
Underlying or contributory	2. 75	—	11	7	44	—	27	—	1	7	18	1
Duodenal ulcer (541)	2. 13	—	—	8	13	—	16	—	—	9	6	1
Underlying or contributory	2. 06	—	—	12	25	—	26	—	—	12	12	2
Cirrhosis of liver (581)	1. 08	—	—	23	19	—	19	—	—	10	9	—
Other diseases of liver, etc. (580, 582–587)	1. 51	—	—	9	14	—	16	—	—	8	8	—
Violence (800–962, 970–991)	1. 02	18	97	79	104	—	109	3	6	49	49	2
Ill-defined and unknown (780–795, XXX)†	1. 54	5	11	36	148	—	94	1	1	30	60	2
All other	1. 22	17	—	37	98	—	90	2	—	33	47	8

See footnotes at end of Appendix table A.

APPENDIX TABLE A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

	EX-SMOKERS WHO STOPPED FOR REASONS OTHER THAN "DR'S. ORDERS"—EX-SMOKERS OF CIGARETTES ONLY—1-9/DAY					
	Total 35–84	35–44	45–54	55–64	65–74	75–84
Person-years of observation:	22,908	1,485	742	10,775	9,286	620

Cause of death (underlying cause unless otherwise specified, International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10⁵*					Number of deaths					
		35–44	45–54	55–64	65–74	75–84	Total 35–84	35–44	45–54	55–64	65–74	75–84
All causes	1. 15	288	378	1, 206	2, 805	—	433	4	3	154	235	37
Cancer, all sites (140–205)	1. 15	—	82	206	497	—	77	—	1	29	42	5
Cancer of buccal cavity (140–144)	—	—	—	—	—	—	—	—	—	—	—	—
Cancer of pharynx (145–148)	—	—	—	—	—	—	—	—	—	—	—	—
Cancer of esophagus (150)	1. 55	—	—	—	13	—	1	—	—	—	1	—
Cancer of stomach (151)	. 96	—	—	25	8	—	5	—	—	4	1	—
Cancer of intestines (152–153)	1. 12	—	82	30	78	—	12	—	1	5	5	1
Cancer of rectum (154)	. 59	—	—	12	38	—	3	—	—	1	2	—
Cancer of pancreas (157)	1. 04	—	—	6	45	—	5	—	—	1	4	—
Cancer of larynx (161)	5. 66	—	—	—	—	—	1	—	—	—	—	1
Cancer of lung and bronchus (162–163)	. 95	—	—	5	31	—	4	—	—	1	3	—
Cancer of prostate (177)	1. 21	—	—	5	70	—	8	—	—	1	7	—
Cancer of kidney (180)	2. 42	—	—	18	25	—	5	—	—	3	2	—
Cancer of bladder and other (181)	1. 02	—	—	—	43	—	3	—	—	—	3	—
Malignant lymphoma (200, 201, 203)	1. 06	—	—	22	42	—	7	—	—	3	4	—
Leukemia (204)	2. 48	—	—	55	49	—	10	—	—	5	5	—
All other sites (155–156, 158–160, 164–165, 170–176, 178–179, 190–199, 202, 205)	1. 02	—	—	28	56	—	13	—	—	5	5	3
Bronchitis and/or emphysema	2. 32	—	—	10	20	—	4	—	—	2	2	—
Bronchitis (500–502)	—	—	—	—	—	—	—	—	—	—	—	—
Underlying or contributory	1. 07	—	—	—	13	—	2	—	—	—	1	1
Emphysema without bronchitis (527.1)	3. 94	—	—	10	20	—	4	—	—	2	2	—
Underlying or contributory	1. 26	—	—	10	39	—	5	—	—	2	3	—
Respiratory tuberculosis (001–008)	1. 13	—	—	—	7	—	1	—	—	—	1	—

Underlying or contributory	1.48	—	—	—	23	—	3	—	—	—	3	—
Asthma (241)	—	—	—	—	—	—	—	—	—	—	—	—
Underlying or contributory	.48	—	—	—	8	—	1	—	—	—	1	—
Influenza and pneumonia (480–493)	1.31	—	110	—	20	—	3	—	1	—	2	—
Underlying or contributory	1.37	—	110	85	263	—	37	—	1	10	23	3
Other respiratory disease (470–475, 510–526, 527.0, 527.2)	.43	—	—	5	—	—	1	—	—	1	—	—
Underlying or contributory	1.41	—	—	16	68	—	11	—	—	3	6	2
Total cardiovascular disease (330–334, 400–468)	1.11	127	186	750	1,777	—	273	2	1	96	146	28
Cerebral vascular lesions (330–334)	.96	—	—	109	189	—	33	—	—	12	14	7
Underlying or contributory	1.09	—	—	140	401	—	58	—	—	18	29	11
Chronic rheumatic heart disease (410–416)	.63	—	—	10	16	—	3	—	—	2	1	—
Underlying or contributory	1.50	—	—	18	101	—	12	—	—	3	9	—
Arteriosclerotic (coronary) heart disease (420)	1.08	58	186	439	1,157	—	174	1	1	61	100	11
Underlying or contributory	1.06	58	186	558	1,323	—	200	1	1	73	111	14
Nonrheumatic endocarditis, etc. (421–422)	1.65	68	—	54	43	—	12	1	—	5	4	2
Underlying or contributory	1.23	68	—	70	91	—	19	1	—	8	7	3
Other heart disease (430–434)	1.62	—	—	—	95	—	8	—	—	—	7	1
Underlying or contributory	1.26	—	—	64	208	—	32	—	—	11	18	3
Hypertension with heart disease (440–443)	.90	—	—	74	80	—	11	—	—	4	7	—
Underlying or contributory	1.15	—	—	167	220	—	38	—	—	16	19	3
Hypertension without heart disease (444–447)	1.13	—	—	10	—	—	3	—	—	2	—	1
Underlying or contributory	1.05	—	—	34	25	—	8	—	—	5	2	1
General arteriosclerosis (450)	1.50	—	—	10	144	—	17	—	—	2	10	5
Underlying or contributory	1.50	—	—	153	402	—	58	—	—	12	31	15
Nonsyphilitic aneurysm of aorta (451)	1.91	—	—	18	54	—	6	—	—	3	2	1
Other circulatory disease (400–402, 452–468)	1.43	—	—	29	8	—	6	—	—	5	1	—
Chronic nephritis, etc. (592–594)	.57	—	—	—	19	—	1	—	—	—	1	—
Underlying or contributory	.78	—	—	5	19	—	3	—	—	1	1	1
Diabetes mellitus (260)	.43	—	—	6	—	—	1	—	—	1	—	—
Underlying or contributory	.80	—	—	33	95	—	16	—	—	5	8	3
Paralysis agitans (350)	1.54	—	—	—	73	—	5	—	—	—	5	—
Underlying or contributory	1.32	—	—	10	115	—	9	—	—	2	7	—
Stomach ulcer (540)	1.57	—	—	—	16	—	1	—	—	—	1	—
Underlying or contributory	1.17	—	—	—	39	—	2	—	—	—	2	—
Duodenal ulcer (541)	1.46	—	—	5	8	—	2	—	—	1	1	—
Underlying or contributory	1.73	—	—	5	32	—	4	—	—	1	3	—
Cirrhosis of liver (581)	1.32	—	—	37	16	—	4	—	—	2	2	—
Other diseases of liver, etc. (580, 582–587)	2.63	—	—	24	16	—	5	—	—	3	2	—
Violence (800–962, 970–991)	1.16	54	—	68	122	—	20	1	—	6	11	2
Ill-defined and unknown (780–795, XXX)†	1.25	—	—	53	103	—	14	—	—	7	7	—
All other	1.58	108	—	46	134	—	21	1	—	6	12	2

See footnotes at end of Appendix table A.

Appendix table A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

	EX-SMOKERS WHO STOPPED FOR REASONS OTHER THAN "DR'S. ORDERS"—EX-SMOKERS OF CIGARETTES ONLY—10-20/DAY					
	Total 35–84	35–44	45–54	55–64	65–74	75–84
Person-years of observation:	68, 094	7, 368	2, 842	32, 930	23, 926	1, 029

Cause of death (underlying cause unless otherwise specified, International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10⁵* 35–44	45–54	55–64	65–74	75–84	Number of deaths Total 35–84	35–44	45–54	55–64	65–74	75–84
All causes	1. 28	69	519	1, 272	3, 243	—	1, 275	6	15	498	688	68
Cancer, all sites (140–205)	1. 27	11	129	207	646	—	226	1	3	86	123	13
Cancer of buccal cavity (140–144)	1. 87	—	—	8	14	—	3	—	—	2	1	—
Cancer of pharynx (145–148)	1. 76	—	—	—	3	—	1	—	—	—	1	—
Cancer of esophagus (150)	—	—	—	—	—	—	—	—	—	—	—	—
Cancer of stomach (151)	. 65	11	—	3	37	—	9	1	—	2	5	1
Cancer of intestines (152–153)	1. 07	—	25	26	91	—	31	—	1	10	20	—
Cancer of rectum (154)	. 85	—	—	12	23	—	12	—	—	7	4	1
Cancer of pancreas (157)	. 80	—	—	15	24	—	10	—	—	6	4	—
Cancer of larynx (161)	9. 33	—	—	—	26	—	4	—	—	—	4	—
Cancer of lung and bronchus (162–163)	3. 48	—	—	48	98	—	39	—	—	17	20	2
Cancer of prostate (177)	1. 48	—	—	12	68	—	24	—	—	6	14	4
Cancer of kidney (180)	1. 77	—	—	5	29	—	10	—	—	3	6	1
Cancer of bladder and other (181)	1. 92	—	—	9	61	—	14	—	—	5	9	—
Malignant lymphoma (200, 201, 203)	1. 18	—	52	27	69	—	21	—	1	9	10	1
Leukemia (204)	1. 19	—	—	9	36	—	13	—	—	5	7	1
All other sites (155–156, 158–160, 164–165, 170–176, 178–179, 190–199, 202, 205)	1. 00	—	52	33	69	—	35	—	1	14	18	2
Bronchitis and/or emphysema	11. 35	—	—	23	167	—	49	—	—	13	36	—
Bronchitis (500–502)	3. 28	—	—	2	21	—	6	—	—	1	5	—
Underlying or contributory	2. 08	—	—	5	27	—	10	—	—	3	7	—
Emphysema without bronchitis (527.1)	17. 28	—	—	21	146	—	43	—	—	12	31	—
Underlying or contributory	7. 29	—	—	32	237	—	72	—	—	18	50	4
Respiratory tuberculosis (001–008)	. 89	—	—	2	3	—	2	—	—	1	1	—

Underlying or contributory	1. 15	—	—	11	3	—	6	—	—	5	1	—
Asthma (241)	1. 49	—	—	2	4	—	2	—	—	1	1	—
Underlying or contributory	3. 36	—	—	14	57	—	19	—	—	7	12	—
Influenza and pneumonia (480–493)	. 70	—	—	2	12	—	4	—	—	1	3	—
Underlying or contributory	1. 34	—	59	81	250	—	91	—	1	34	46	10
Other respiratory diseases (470–475, 510–526, 527.0, 527.2)	1. 22	—	—	2	34	—	7	—	—	1	6	—
Underlying or contributory	1. 31	—	52	7	101	—	26	—	1	4	20	1
Total cardiovascular disease (330–334, 400–468)	1. 26	11	189	848	2, 000	—	816	1	6	324	432	53
Cerebral vascular lesions (330–334)	1. 14	—	59	71	238	—	98	—	1	33	53	11
Underlying or contributory	1. 18	—	59	124	411	—	159	—	1	53	90	15
Chronic rheumatic heart disease (410–416)	1. 22	—	—	21	44	—	16	—	—	8	8	—
Underlying or contributory	1. 36	—	—	28	104	—	30	—	—	11	19	—
Arteriosclerotic (coronary) heart disease (420)	1. 25	11	99	607	1, 288	—	539	1	4	227	281	26
Underlying or contributory	1. 24	11	151	678	1, 550	—	620	1	5	253	329	32
Nonrheumatic endocarditis, etc. (421–422)	1. 08	—	—	15	63	—	20	—	—	7	12	1
Underlying or contributory	1. 28	—	—	50	143	—	50	—	—	18	30	2
Other heart disease (430–434)	1. 60	—	—	17	39	—	20	—	—	8	11	1
Underlying or contributory	1. 94	—	52	108	330	—	128	—	1	45	75	7
Hypertension with heart disease (440–443)	1. 50	—	30	60	133	—	49	—	1	17	28	3
Underlying or contributory	1. 23	—	30	114	279	—	109	—	1	42	60	6
Hypertension without heart disease (444–447)	1. 97	—	—	13	49	—	14	—	—	6	8	—
Underlying or contributory	1. 57	—	—	39	88	—	32	—	—	14	17	1
General arteriosclerosis (450)	. 76	—	—	9	47	—	20	—	—	5	8	7
Underlying or contributory	1. 05	—	—	60	252	—	97	—	—	28	54	15
Nonsyphilitic aneurysm of aorta (451)	3. 40	—	—	22	82	—	28	—	—	9	16	3
Other circulatory disease (400–402, 452–468)	1. 12	—	—	16	29	—	12	—	—	4	7	1
Chronic nephritis, etc. (592–594)	1. 51	12	—	8	13	—	7	1	—	2	4	—
Underlying or contributory	1. 33	12	—	23	22	—	14	1	—	6	6	1
Diabetes mellitus (260)	—	—	—	—	—	—	—	—	—	—	—	—
Underlying or contributory	. 95	—	—	51	131	—	49	—	—	18	29	2
Paralysis agitans (350)	. 86	—	—	5	22	—	7	—	—	2	5	—
Underlying or contributory	. 82	—	—	8	46	—	14	—	—	4	10	—
Stomach ulcer (540)	3. 48	—	—	8	21	—	6	—	—	3	3	—
Underlying or contributory	3. 91	—	22	12	55	—	18	—	1	5	11	1
Duodenal ulcer (541)	2. 55	—	—	9	24	—	9	—	—	4	5	—
Underlying or contributory	2. 20	—	—	15	27	—	13	—	—	6	6	1
Cirrhosis of liver (581)	. 61	—	—	15	17	—	5	—	—	3	2	—
Other diseases of liver, etc. (580, 582–587)	1. 00	—	—	2	17	—	5	—	—	1	4	—
Violence (800–962, 970–991)	1. 01	24	177	71	74	—	51	2	5	27	17	—
Ill-defined and unknown (780–795, XXX)†	1. 46	10	26	27	137	—	42	1	1	12	23	—
All other	1. 07	—	—	47	86	—	37	—	—	17	18	2

See footnotes at end of Appendix table A.

APPENDIX TABLE A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

EX-SMOKERS WHO STOPPED FOR REASONS OTHER THAN "DR'S. ORDERS"—EX-SMOKERS OF CIGARETTES ONLY—21–39/DAY

	Total 35–84	35–44	45–54	55–64	65–74	75–84
Person-years of observation:	39,740	4,820	1,892	20,267	12,320	441

Cause of death (underlying cause unless otherwise specified, International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10⁵*					Number of deaths					
		35–44	45–54	55–64	65–74	75–84	Total 35–84	35–44	45–54	55–64	65–74	75–84
All causes	1. 53	59	249	1, 798	3, 592	—	828	3	6	386	401	32
Cancer, all sites (140–205)	1. 77	—	134	423	736	—	173	—	3	82	83	5
Cancer of buccal cavity (140–144)	4. 49	—	—	13	5	—	4	—	—	3	1	—
Cancer of pharynx (145–148)	—	—	—	—	—	—	—	—	—	—	—	—
Cancer of esophagus (150)	3. 87	—	—	3	19	—	3	—	—	1	2	—
Cancer of stomach (151)	. 78	—	—	15	21	—	6	—	—	4	2	—
Cancer of intestines (152–153)	1. 25	—	33	51	66	—	20	—	1	9	10	—
Cancer of rectum (154)	1. 13	—	—	21	54	—	9	—	—	3	5	1
Cancer of pancreas (157)	1. 48	—	—	13	31	—	10	—	—	4	5	1
Cancer of larynx (161)	15. 74	—	—	15	6	—	4	—	—	3	1	—
Cancer of lung and bronchus (162–163)	9. 33	—	33	176	219	—	57	—	1	28	26	2
Cancer of prostate (177)	2. 03	—	—	22	118	—	17	—	—	6	11	—
Cancer of kidney (180)	1. 27	—	67	3	5	—	4	—	1	1	1	1
Cancer of bladder and other (181)	1. 30	—	—	15	11	—	5	—	—	4	1	—
Malignant lymphoma (200, 201, 203)	. 80	—	—	23	21	—	8	—	—	4	4	—
Leukemia (204)	1. 16	—	—	3	93	—	7	—	—	1	6	—
All other sites (155–156, 158–160, 164–165, 170–176, 178–179, 190–199, 202, 205)	. 97	—	—	51	67	—	19	—	—	11	8	—
Bronchitis and/or emphysema	12. 68	—	—	69	102	—	29	—	—	15	13	1
Bronchitis (500–502)	7. 24	—	—	20	13	—	7	—	—	5	2	—
Underlying or contributory	5. 14	—	—	28	37	—	13	—	—	7	5	1
Emphysema without bronchitis (527.1)	16. 66	—	—	48	89	—	22	—	—	10	11	1
Underlying or contributory	9. 64	—	—	112	295	—	50	—	—	22	27	1
Respiratory tuberculosis (001–008)	2. 54	—	—	7	—	—	3	—	—	2	—	1

Underlying or contributory	3. 98	—	—	17	27	—	11	—	—	5	4	2
Asthma (241)	6. 34	—	—	35	14	—	5	—	—	4	1	—
Underlying or contributory	5. 06	—	—	57	46	—	16	—	—	10	6	—
Influenza and pneumonia (480–493)	. 34	—	—	—	8	—	1	—	—	—	1	—
Underlying or contributory	1. 64	—	—	78	336	—	58	—	—	22	32	4
Other respiratory disease (470–475, 510–526, 527.0, 527.2)	2. 31	—	—	14	50	—	7	—	—	3	4	—
Underlying or contributory	1. 70	—	—	29	83	—	18	—	—	8	10	—
Total cardiovascular disease (330–334, 400–468)	1. 46	34	66	1, 020	2, 234	—	512	2	2	240	248	20
Cerebral vascular lesions (330–334)	1. 18	16	—	59	278	—	53	1	—	17	30	5
Underlying or contributory	1. 25	41	—	111	445	—	89	2	—	32	47	8
Chronic rheumatic heart disease (410–416)	1. 34	—	—	17	43	—	10	—	—	5	5	—
Underlying or contributory	1. 63	—	—	29	84	—	20	—	—	8	12	—
Arteriosclerotic (coronory) heart disease (420)	1. 50	18	66	776	1, 551	—	353	1	2	174	167	9
Underlying or contributory	1. 50	18	66	857	1, 816	—	409	1	2	197	197	12
Nonrheumatic endocarditis, etc. (421–422)	1. 31	—	—	15	79	—	13	—	—	5	8	—
Underlying or contributory	1. 48	—	—	39	162	—	31	—	—	13	18	—
Other heart disease (430–434)	1. 51	—	—	27	25	—	10	—	—	6	4	—
Underlying or contributory	1. 98	—	33	171	369	—	71	—	1	37	33	—
Hypertension with heart disease (440–443)	1. 28	—	—	43	105	—	23	—	—	11	10	2
Underlying or contributory	1. 48	—	—	173	284	—	72	—	—	36	30	6
Hypertension without heart disease (444–447)	1. 25	—	—	13	6	—	5	—	—	4	1	—
Underlying or contributory	1. 06	—	—	35	11	—	12	—	—	10	2	—
General arteriosclerosis (450)	1. 19	—	—	17	51	—	16	—	—	5	9	2
Underlying or contributory	1. 34	—	—	106	248	—	64	—	—	26	33	5
Nonsyphilitic aneurysm of aorta (451)	3. 65	—	—	15	66	—	16	—	—	4	10	2
Other circulatory disease (400–402, 452–468)	2. 25	—	—	41	42	—	13	—	—	9	4	—
Chronic nephritis, etc. (592–594)	2. 72	—	—	15	24	—	7	—	—	4	3	—
Underlying or contributory	2. 03	—	—	24	34	—	12	—	—	7	5	—
Diabetes mellitus (260)	1. 28	—	—	9	12	—	4	—	—	2	2	—
Underlying or contributory	1. 52	—	33	64	163	—	42	—	1	19	21	1
Paralysis agitans (350)	—	—	—	—	—	—	—	—	—	—	—	—
Underlying or contributory	. 22	—	—	—	5	—	2	—	—	—	1	1
Stomach ulcer (540)	1. 07	—	—	—	5	—	1	—	—	—	1	—
Underlying or contributory	1. 97	—	—	6	15	—	5	—	—	2	3	—
Duodenal ulcer (541)	1. 05	—	—	7	—	—	2	—	—	2	—	—
Underlying or contributory	1. 89	—	—	10	26	—	6	—	—	3	3	—
Cirrhosis of liver (581)	1. 29	—	—	34	16	—	6	—	—	4	2	—
Other diseases of liver, etc. (580, 582–587)	1. 86	—	—	15	6	—	5	—	—	4	1	—
Violence (800–962, 970–991)	. 99	—	49	101	171	—	29	—	1	11	17	—
Ill-defined and unknown (780–795, XXX)†	1. 77	—	—	44	180	—	27	—	—	8	17	2
All other	. 91	25	—	17	72	—	17	1	—	5	8	3

See footnotes at end of Appendix table A.

Appendix table A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

EX-SMOKERS WHO STOPPED FOR REASONS OTHER THAN "DR'S. ORDERS"—EX-SMOKERS OF CIGARETTES ONLY—OVER 39/DAY

	Total 35–84	35–44	45–54	55–64	65–74	75–84
Person-years of observation:	13,939	1,006	557	7,421	4,810	145

Cause of death (underlying cause unless otherwise specified, International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10^5*					Number of deaths					
		35–44	45–54	55–64	65–74	75–84	Total 35–84	35–44	45–54	55–64	65–74	75–84
All causes	1. 60	—	—	1, 545	4, 192	—	325	—	—	132	184	9
Cancer, all sites (140–205)	1. 86	—	—	481	898	—	68	—	—	31	34	3
Cancer of buccal cavity (140–144)	—	—	—	—	—	—	—	—	—	—	—	—
Cancer of pharynx (145–148)	—	—	—	—	—	—	—	—	—	—	—	—
Cancer of esophagus (150)	3. 47	—	—	8	—	—	1	—	—	1	—	—
Cancer of stomach (151)	2. 10	—	—	44	104	—	6	—	—	4	2	—
Cancer of intestines (152–153)	1. 33	—	—	17	102	—	8	—	—	1	7	—
Cancer of rectum (154)	. 67	—	—	—	33	—	2	—	—	—	2	—
Cancer of pancreas (157)	2. 35	—	—	65	150	—	6	—	—	3	3	—
Cancer of larynx (161)	11. 08	—	—	8	—	—	1	—	—	1	—	—
Cancer of lung and bronchus (162–163)	8. 24	—	—	68	327	—	19	—	—	7	11	1
Cancer of prostate (177)	. 95	—	—	44	—	—	3	—	—	3	—	—
Cancer of kidney (180)	1. 68	—	—	—	28	—	2	—	—	—	2	—
Cancer of bladder and other (181)	1. 38	—	—	—	43	—	2	—	—	—	1	1
Malignant lymphoma (200, 201, 203)	1. 89	—	—	180	16	—	7	—	—	6	1	—
Leukemia (204)	1. 34	—	—	—	49	—	3	—	—	—	2	—
All other sites (155–156, 158–160, 164–165, 170–176, 178–179, 190–199, 202, 205)	1. 11	—	—	49	50	—	8	—	—	5	3	—
Bronchitis and/or emphysema	13. 99	—	—	—	265	—	12	—	—	—	12	—
Bronchitis (500–502)	16. 21	—	—	—	120	—	6	—	—	—	6	—
Underlying or contributory	9. 39	—	—	17	177	—	9	—	—	2	7	—
Emphysema without bronchitis (527.1)	12. 30	—	—	—	145	—	6	—	—	—	6	—
Underlying or contributory	9. 21	—	—	8	437	—	18	—	—	1	17	—
Respiratory tuberculosis (001–008)	—	—	—	—	—	—	—	—	—	—	—	—

Underlying or contributory	. 95	—	—	—	22	—	1	—	—	—	1	1
Asthma (241)	—	—	—	—	—	—	—	—	—	—	—	—
Underlying or contributory	3. 36	—	—	16	41	—	4	—	—	2	2	—
Influenza and pneumonia (480–493)	1. 80	—	—	24	—	—	2	—	—	2	—	—
Underlying or contributory	1. 80	—	—	74	383	—	24	—	—	7	16	—
Other respiratory disease (470–475, 510–526, 527.0, 527.2)	1. 80	—	—	35	—	—	2	—	—	2	—	—
Underlying or contributory	3. 04	—	—	103	143	—	12	—	—	8	4	—
Total cardiovascular disease (330–334, 400–468)	1. 46	—	—	863	2, 454	—	193	—	—	80	109	4
Cerebral vascular lesions (330–334)	1. 47	—	—	60	380	—	25	—	—	7	18	—
Underlying or contributory	1. 60	—	—	142	524	—	43	—	—	15	26	2
Chronic rheumatic heart disease (410–416)	. 71	—	—	16	—	—	2	—	—	2	—	—
Underlying or contributory	. 86	—	—	16	28	—	4	—	—	2	1	1
Arteriosclerotic (coronary) heart disease (420)	1. 42	—	—	640	1, 496	—	126	—	—	55	67	4
Underlying or contributory	1. 50	—	—	703	1, 911	—	154	—	—	62	87	5
Nonrheumatic endocarditis, etc. (421–422)	. 80	—	—	9	85	—	3	—	—	1	2	—
Underlying or contributory	1. 65	—	—	68	130	—	13	—	—	8	5	—
Other heart disease (430–434)	2. 82	—	—	16	143	—	7	—	—	2	5	—
Underlying or contributory	2. 15	—	—	113	344	—	29	—	—	13	16	—
Hypertension with heart disease (440–443)	1. 63	—	—	74	126	—	11	—	—	7	4	—
Underlying or contributory	1. 42	—	—	140	272	—	25	—	—	14	12	—
Hypertension without heart disease (444–447)	—	—	—	—	—	—	—	—	—	—	—	—
Underlying or contributory	1. 41	—	—	25	67	—	6	—	—	3	3	—
General arteriosclerosis (450)	2. 38	—	—	16	194	—	12	—	—	2	10	—
Underlying or contributory	1. 67	—	—	32	519	—	30	—	—	4	23	3
Nonsyphilitic aneurysm of aorta (451)	1. 80	—	—	8	37	—	3	—	—	1	2	—
Other circulatory disease (400–402, 452–468)	1. 86	—	—	26	13	—	4	—	—	3	1	—
Chronic nephritis, etc. (592–594)	1. 07	—	—	9	—	—	1	—	—	1	—	—
Underlying or contributory	1. 83	—	—	9	43	—	4	—	—	1	3	—
Diabetes mellitus (260)	1. 69	—	—	—	79	—	2	—	—	—	2	—
Underlying or contributory	1. 15	—	—	25	264	—	12	—	—	3	8	1
Paralysis agitans (350)	—	—	—	—	—	—	—	—	—	—	—	—
Underlying or contributory	. 29	—	—	—	16	—	1	—	—	—	1	—
Stomach ulcer (540)	5. 59	—	—	—	56	—	2	—	—	—	2	—
Underlying or contributory	2. 07	—	—	—	56	—	2	—	—	—	2	—
Duodenal ulcer (541)	4. 18	—	—	15	—	—	3	—	—	2	—	1
Underlying or contributory	2. 51	—	—	15	—	—	3	—	—	2	—	1
Cirrhosis of liver (581)	2. 31	—	—	8	38	—	4	—	—	1	3	—
Other diseases of liver, etc. (580, 582–587)	. 97	—	—	—	22	—	1	—	—	—	1	—
Violence (800–962, 970–991)	. 87	—	—	50	64	—	9	—	—	5	4	—
Ill-defined and unknown (780–795, XXX)†	1. 90	—	—	25	226	—	11	—	—	3	8	—
All other	2. 15	—	—	41	149	—	15	—	—	5	9	1

See footnotes at end of Appendix table A.

APPENDIX TABLE A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

	EX-SMOKERS WHO STOPPED FOR REASONS OTHER THAN "DR'S. ORDERS"—EX-SMOKERS OF PIPES AND/OR CIGARS ONLY—TOTAL					
	Total 35–84	35–44	45–54	55–64	65–74	75–84
Person-years of observation:	53,737	1,648	1,073	25,056	24,125	1,835

Cause of death (underlying cause unless otherwise specified, International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10⁵*					Number of deaths					
		35–44	45–54	55–64	65–74	75–84	Total 35–84	35–44	45–54	55–64	65–74	75–84
All causes	1. 25	201	728	1, 241	2, 909	6, 656	1, 205	3	9	401	668	124
Cancer, all sites (140–205)	1. 14	54	301	192	450	960	193	1	4	63	107	18
Cancer of buccal cavity (140–144)	3. 43	—	—	—	14	67	5	—	—	—	4	1
Cancer of pharynx (145–148)	1. 71	—	—	—	5	—	1	—	—	—	1	—
Cancer of esophagus (150)	1. 15	—	—	—	7	—	2	—	—	—	2	—
Cancer of stomach (151)	1. 29	—	42	11	36	159	17	—	1	4	9	3
Cancer of intestines (152–153)	. 92	—	—	23	52	143	25	—	—	10	12	3
Cancer of rectum (154)	1. 03	54	—	29	25	—	13	1	—	7	5	—
Cancer of pancreas (157)	. 64	—	—	7	25	—	8	—	—	3	5	—
Cancer of larynx (161)	—	—	—	—	—	—	—	—	—	—	—	—
Cancer of lung and bronchus (162–163)	1. 50	—	—	5	58	60	16	—	—	2	13	1
Cancer of prostate (177)	1. 53	—	—	20	54	241	27	—	—	9	13	5
Cancer of kidney (180)	. 96	—	99	10	—	80	5	—	1	3	—	1
Cancer of bladder and other (181)	1. 29	—	—	—	40	47	10	—	—	—	9	1
Malignant lymphoma (200, 201, 203)	. 67	—	—	20	35	—	11	—	—	3	8	—
Leukemia (204)	1. 49	—	42	13	19	110	15	—	1	6	6	2
All other sites (155–156, 158–160, 164–165, 170–176, 178–179, 190–199, 202, 205)	1. 20	—	117	56	80	55	38	—	1	16	20	1
Bronchitis and/or emphysema	1. 10	—	—	6	3	87	5	—	—	3	1	1
Bronchitis (500–502)	—	—	—	—	—	—	—	—	—	—	—	—
Underlying or contributory	. 83	—	—	—	15	87	4	—	—	—	3	1
Emphysema without bronchitis (527.1)	1. 85	—	—	6	3	87	5	—	—	3	1	1
Underlying or contributory	1. 63	—	—	19	50	133	17	—	—	5	10	2
Respiratory tuberculosis (001–008)	2. 16	—	—	32	10	—	5	—	—	2	3	—

Underlying or contributory	1. 52	—	—	35	13	36	8	—	—	3	4	1
Asthma (241)	3. 54	—	—	3	12	—	4	—	—	1	3	—
Underlying or contributory	1. 72	—	—	11	15	87	9	—	—	4	4	1
Influenza and pneumonia (480–493)	. 50	—	—	4	5	—	3	—	—	2	1	—
Underlying or contributory	1. 09	—	273	63	226	516	77	—	2	17	48	10
Other respiratory disease (470–475, 510–526, 527.0, 527.2)	1. 31	—	—	3	33	83	8	—	—	1	5	2
Underlying or contributory	1. 49	—	156	22	87	246	30	—	1	8	16	5
Total cardiovascular disease (330–334, 400–468)	1. 32	100	240	841	2, 025	4, 797	836	1	3	286	457	89
Cerebral vascular lesions (330–334)	1. 16	—	156	70	291	586	104	—	1	26	66	11
Underlying or contributory	1. 25	46	156	131	492	1, 092	175	1	1	48	106	19
Chronic rheumatic heart disease (410–416)	1. 86	—	—	20	60	92	22	—	—	7	13	2
Underlying or contributory	1. 40	—	117	32	65	92	28	—	1	11	14	2
Arteriosclerotic (coronary) heart disease (420)	1. 34	100	42	626	1, 263	3, 049	550	1	1	209	282	57
Underlying or contributory	1. 35	100	42	702	1, 574	3, 504	650	1	1	230	352	66
Nonrheumatic endocarditis, etc. (421-422)	1. 39	—	—	11	70	383	26	—	—	5	15	6
Underlying or contributory	1. 48	—	—	62	135	650	59	—	—	18	31	10
Other heart disease (430–434)	1. 40	—	42	9	49	36	18	—	1	4	12	1
Underlying or contributory	1. 52	100	42	81	297	798	99	1	1	23	61	13
Hypertension with heart disease (440–443)	1. 59	—	—	49	136	279	49	—	—	14	30	5
Underlying or contributory	1. 49	—	—	146	286	840	126	—	—	46	65	15
Hypertension without heart disease (444–447)	1. 04	—	—	14	6	107	7	—	—	3	2	2
Underlying or contributory	1. 30	—	—	31	34	290	25	—	—	10	10	5
General arteriosclerosis (450)	1. 12	—	—	25	104	209	34	—	—	9	22	3
Underlying or contributory	1. 16	—	—	102	322	922	119	—	—	32	70	17
Nonsyphilitic aneurysm of aorta (451)	1. 47	—	—	7	34	—	12	—	—	3	9	—
Other circulatory disease (400–402, 452–468)	1. 29	—	—	14	24	112	14	—	—	6	6	2
Chronic nephritis, etc. (592–594)	1. 13	—	—	2	18	—	5	—	—	1	4	—
Underlying or contributory	1. 04	—	—	10	27	—	10	—	—	3	7	—
Diabetes mellitus (260)	. 81	—	—	6	13	—	5	—	—	1	4	—
Underlying or contributory	1. 23	—	—	60	189	255	64	—	—	19	40	5
Paralysis agitans (350)	1. 18	—	—	15	37	60	10	—	—	1	8	1
Underlying or contributory	1. 01	—	—	17	58	157	18	—	—	2	13	3
Stomach ulcer (540)	2. 46	—	—	—	23	60	4	—	—	—	3	1
Underlying or contributory	1. 38	—	—	2	23	127	6	—	—	1	3	2
Duodenal ulcer (541)	2. 22	—	—	2	31	—	8	—	—	1	7	—
Underlying or contributory	2. 13	—	—	8	38	—	13	—	—	4	9	—
Cirrhosis of liver (581)	. 92	—	72	19	6	—	7	—	1	4	2	—
Other diseases of liver, etc. (580, 582–587)	1. 42	—	—	6	10	47	7	—	—	3	3	1
Violence (800–962, 970–991)	1. 07	—	—	57	85	216	44	—	—	18	22	4
Ill-defined and unknown (780–795, XXX)†	. 69	—	—	19	59	166	20	—	—	5	13	2
All other	1. 21	46	117	37	112	286	41	1	1	9	25	5

See footnotes at end of Appendix table A.

APPENDIX TABLE A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

EX-SMOKERS WHO STOPPED FOR REASONS OTHER THAN "DR'S. ORDERS"—EX-SMOKERS OF CIGARS ONLY—TOTAL

	Total 35–84	35–44	45–54	55–64	65–74	75–84
Person-years of observation:	24, 014	444	284	11, 072	11, 295	919

Cause of death (underlying cause unless otherwise specified, International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10⁵* 35–44	45–54	55–64	65–74	75–84	Number of deaths Total 35–84	35–44	45–54	55–64	65–74	75–84
All causes	1. 26	—	—	1, 279	2, 827	—	563	1	4	184	310	64
Cancer, all sites (140–205)	1. 05	—	—	204	387	—	82	—	3	30	45	4
Cancer of buccal cavity (140–144)	3. 00	—	—	—	6	—	2	—	—	—	1	1
Cancer of pharynx (145–148)	3. 67	—	—	—	10	—	1	—	—	—	1	—
Cancer of esophagus (150)	2. 41	—	—	—	14	—	2	—	—	—	2	—
Cancer of stomach (151)	1. 31	—	—	12	45	—	8	—	1	1	5	1
Cancer of intestines (152–153)	. 72	—	—	23	37	—	9	—	—	4	4	1
Cancer of rectum (154)	. 86	—	—	34	14	—	5	—	—	4	1	—
Cancer of pancreas (157)	. 86	—	—	15	13	—	5	—	—	3	2	—
Cancer of larynx (161)	—	—	—	—	—	—	—	—	—	—	—	—
Cancer of lung and bronchus (162–163)	1. 01	—	—	4	47	—	5	—	—	1	4	—
Cancer of prostate (177)	1. 32	—	—	26	34	—	11	—	—	5	5	1
Cancer of kidney (180)	. 84	—	—	4	—	—	2	—	1	1	—	—
Cancer of bladder and other (181)	1. 10	—	—	—	29	—	4	—	—	—	4	—
Malignant lymphoma (200, 201, 203)	. 66	—	—	38	37	—	5	—	—	1	4	—
Leukemia (204)	1. 08	—	—	15	15	—	5	—	—	3	2	—
All other sites (155–156, 158–160, 164–165, 170–176, 178–179, 190–199, 202, 205)	1. 24	—	—	33	85	—	18	—	1	7	10	—
Bronchitis and/or emphysema	1. 38	—	—	9	—	—	3	—	—	2	—	1
Bronchitis (500–502)	—	—	—	—	—	—	—	—	—	—	—	—
Underlying or contributory	. 89	—	—	—	15	—	2	—	—	—	2	—
Emphysema without bronchitis (527.1)	2. 29	—	—	9	—	—	3	—	—	2	—	1
Underlying or contributory	1. 21	—	—	9	34	—	6	—	—	2	3	1
Respiratory tuberculosis (001–008)	. 92	—	—	—	6	—	1	—	—	—	1	—
Underlying or contributory	1. 22	—	—	8	6	—	3	—	—	1	1	1

Asthma (241)	—	—	—	—	—	—	—	—	—	—	—	—
Underlying or contributory	.41	—	—	4	—	—	1	—	—	1	—	—
Influenza and pneumonia (480–493)	.71	—	—	4	10	—	2	—	—	1	1	—
Underlying or contributory	1.24	—	—	90	216	—	41	—	1	12	22	6
Other respiratory disease (470–475, 510–526, 527.0, 527.2)	.35	—	—	—	13	—	1	—	—	—	1	—
Underlying or contributory	1.06	—	—	4	77	—	10	—	1	1	8	—
Total cardiovascular disease (330–334, 400–468)	1.37	—	—	905	2,048	—	402	—	1	130	220	51
Cerebral vascular lesions (330–334)	1.14	—	—	65	278	—	48	—	1	12	31	4
Underlying or contributory	1.21	—	—	141	435	—	79	1	1	22	46	9
Chronic rheumatic heart disease (410–416)	2.03	—	—	26	52	—	11	—	—	4	6	1
Underlying or contributory	1.41	—	—	32	52	—	13	—	1	5	6	1
Arteriosclerotic (coronary) heart disease (420)	1.41	—	—	673	1,294	—	268	—	—	95	138	35
Underlying or contributory	1.42	—	—	750	1,609	—	318	—	—	105	173	40
Nonrheumatic endocarditis, etc. (421–422)	1.25	—	—	9	74	—	11	—	—	2	7	2
Underlying or contributory	1.24	—	—	29	123	—	23	—	—	6	13	4
Other heart disease (430–434)	.83	—	—	4	28	—	5	—	—	1	3	1
Underlying or contributory	1.42	—	—	60	247	—	43	—	—	11	25	7
Hypertension with heart disease (440–443)	1.61	—	—	68	102	—	23	—	—	8	12	3
Underlying or contributory	1.56	—	—	178	250	—	61	—	—	22	30	9
Hypertension without heart disease (444–447)	.64	—	—	24	—	—	2	—	—	1	—	1
Underlying or contributory	1.24	—	—	33	39	—	11	—	—	3	5	3
General arteriosclerosis (450)	1.52	—	—	18	169	—	22	—	—	3	16	3
Underlying or contributory	1.44	—	—	109	423	—	70	—	—	15	44	11
Nonsyphilitic aneurysm of aorta (451)	2.13	—	—	11	53	—	8	—	—	2	6	—
Other circulatory disease (400–402, 452–468)	.78	—	—	9	13	—	4	—	—	2	1	1
Chronic nephritis, etc. (592–594)	2.44	—	—	4	38	—	5	—	—	1	4	—
Underlying or contributory	1.36	—	—	4	45	—	6	—	—	1	5	—
Diabetes mellitus (260)	.34	—	—	—	7	—	1	—	—	—	1	—
Underlying or contributory	1.20	—	—	55	165	—	29	—	—	8	18	3
Paralysis agitans (350)	.50	—	—	—	14	—	2	—	—	—	1	1
Underlying or contributory	.60	—	—	4	35	—	5	—	—	1	3	1
Stomach ulcer (540)	2.68	—	—	—	33	—	2	—	—	—	2	—
Underlying or contributory	1.49	—	—	4	33	—	3	—	—	1	2	—
Duodenal ulcer (541)	1.80	—	—	—	25	—	3	—	—	—	3	—
Underlying or contributory	1.41	—	—	—	32	—	4	—	—	—	4	—
Cirrhosis of liver (581)	1.15	—	—	21	6	—	4	—	—	3	1	—
Other diseases of liver, etc. (580, 582–587)	2.64	—	—	9	21	—	6	—	—	2	3	1
Violence (800–962, 970–991)	1.19	—	—	63	111	—	22	—	—	8	13	1
Ill-defined and unknown (780–795, XXX)†	.66	—	—	40	29	—	9	—	—	4	3	2
All other	1.14	—	—	23	97	—	18	1	—	3	11	3

See footnotes at end of Appendix table A.

Appendix table A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

	EX-SMOKERS WHO STOPPED FOR REASONS OTHER THAN "DR'S. ORDERS"—EX-SMOKERS OF PIPES ONLY—TOTAL					
	Total 35–84	35–44	45–54	55–64	65–74	75–84
Person-years of observation:	15, 660	860	509	7, 301	6, 560	429

Cause of death (underlying cause unless otherwise specified, International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10⁵*					Number of deaths					
		35–44	45–54	55–64	65–74	75–84	Total 35–84	35–44	45–54	55–64	65–74	75–84
All causes	1. 20	—	—	1, 264	2, 723	—	316	2	4	112	169	29
Cancer, all sites (140–205)	1. 19	—	—	176	454	—	55	1	1	15	29	9
Cancer of buccal cavity (140–144)	2. 47	—	—	—	11	—	1	—	—	—	1	—
Cancer of pharynx (145–148)	—	—	—	—	—	—	—	—	—	—	—	—
Cancer of esophagus (150)	—	—	—	—	—	—	—	—	—	—	—	—
Cancer of stomach (151)	1. 11	—	—	7	34	—	4	—	—	1	2	1
Cancer of intestines (152–153)	1. 07	—	—	22	32	—	8	—	—	3	3	2
Cancer of rectum (154)	1. 98	—	—	47	54	—	7	1	—	3	3	—
Cancer of pancreas (157)	. 60	—	—	—	30	—	2	—	—	—	2	—
Cancer of larynx (161)	—	—	—	—	—	—	—	—	—	—	—	—
Cancer of lung and bronchus (162–163)	2. 39	—	—	—	101	—	7	—	—	—	6	1
Cancer of prostate (177)	1. 07	—	—	—	89	—	5	—	—	—	4	1
Cancer of kidney (180)	. 69	—	—	18	—	—	1	—	—	1	—	—
Cancer of bladder and other (181)	. 49	—	—	—	—	—	1	—	—	—	—	1
Malignant lymphoma (200, 201, 203)	. 44	—	—	7	15	—	2	—	—	1	1	—
Leukemia (204)	2. 16	—	—	8	23	—	6	—	1	1	2	2
All other sites (155–156, 158–160, 164–165, 170–176, 178–179, 190–199, 202, 205)	1. 24	—	—	67	66	—	11	—	—	5	5	1
Bronchitis and/or emphysema	1. 64	—	—	8	11	—	2	—	—	1	1	—
Bronchitis (500–502)	—	—	—	—	—	—	—	—	—	—	—	—
Underlying or contributory	1. 53	—	—	—	31	—	2	—	—	—	1	1
Emphysema without bronchitis (527.1)	2. 77	—	—	8	11	—	2	—	—	1	1	—
Underlying or contributory	2. 51	—	—	19	71	—	7	—	—	2	5	—
Respiratory tuberculosis (001–008)	3. 22	—	—	76	15	—	2	—	—	1	1	—

Underlying or contributory	1. 41	—	—	76	15	—	2	—	—	1	1	—
Asthma (241)	6. 27	—	—	11	15	—	2	—	—	1	1	—
Underlying or contributory	4. 13	—	—	30	27	—	6	—	—	3	2	1
Influenza and pneumonia (480–493)	. 62	—	—	7	—	—	1	—	—	1	—	—
Underlying or contributory	. 90	—	—	64	202	—	17	—	1	3	11	2
Other respiratory disease (470–475, 510–526, 527.0, 527.2)	2. 46	—	—	9	53	—	4	—	—	1	2	1
Underlying or contributory	2. 01	—	—	53	53	—	11	—	—	5	2	4
Total cardiovascular disease (330–334, 400–468)	1. 19	—	—	777	1, 731	—	204	1	1	79	108	15
Cerebral vascular lesions (330–334)	1. 04	—	—	31	281	—	25	—	—	4	17	4
Underlying or contributory	1. 18	—	—	61	543	—	44	—	—	8	31	5
Chronic rheumatic heart disease (410–416)	2. 13	—	—	19	58	—	7	—	—	2	4	1
Underlying or contributory	1. 44	—	—	37	58	—	8	—	—	3	4	1
Arteriosclerotic (coronary) heart disease (420)	1. 22	—	—	617	1, 090	—	137	1	1	61	65	9
Underlying or contributory	1. 24	—	—	665	1, 354	—	163	1	1	67	83	11
Nonrheumatic endocarditis, etc. (421–422)	. 59	—	—	9	15	—	3	—	—	1	1	1
Underlying or contributory	1. 31	—	—	109	68	—	14	—	—	7	4	3
Other heart disease (430–434)	1. 45	—	—	9	50	—	5	—	—	1	4	—
Underlying or contributory	1. 19	—	—	120	152	—	21	1	—	6	10	4
Hypertension with heart disease (440–443)	1. 53	—	—	37	151	—	13	—	—	3	10	—
Underlying or contributory	1. 38	—	—	121	283	—	32	—	—	12	18	2
Hypertension without heart disease (444–447)	. 54	—	—	—	12	—	1	—	—	—	1	—
Underlying or contributory	1. 13	—	—	9	48	—	6	—	—	1	4	1
General arteriosclerosis (450)	. 88	—	—	32	39	—	7	—	—	4	3	—
Underlying or contributory	1. 07	—	—	126	255	—	29	—	—	11	15	3
Nonsyphilitic aneurysm of aorta (451)	—	—	—	—	—	—	—	—	—	—	—	—
Other circulatory disease (400–402, 452–468)	2. 05	—	—	26	45	—	6	—	—	3	3	—
Chronic nephritis, etc. (592–594)	—	—	—	—	—	—	—	—	—	—	—	—
Underlying or contributory	. 75	—	—	8	12	—	2	—	—	1	1	—
Diabetes mellitus (260)	. 61	—	—	—	15	—	1	—	—	—	1	—
Underlying or contributory	1. 00	—	—	61	125	—	14	—	—	6	7	1
Paralysis agitans (350)	2. 20	—	—	48	76	—	5	—	—	1	4	—
Underlying or contributory	1. 88	—	—	48	106	—	9	—	—	1	6	2
Stomach ulcer (540)	2. 24	—	—	—	—	—	1	—	—	—	—	1
Underlying or contributory	. 84	—	—	—	—	—	1	—	—	—	—	1
Duodenal ulcer (541)	2. 07	—	—	—	44	—	2	—	—	—	2	—
Underlying or contributory	1. 83	—	—	—	59	—	3	—	—	—	3	—
Cirrhosis of liver (581)	. 94	—	—	—	11	—	2	—	1	—	1	—
Other diseases of liver, etc. (580, 582–587)	—	—	—	—	—	—	—	—	—	—	—	—
Violence (800–962, 970–991)	1. 10	—	—	67	74	—	13	—	—	6	5	2
Ill-defined and unknown (780–795, XXX)†	. 89	—	—	7	127	—	7	—	—	1	6	—
All other	1. 62	—	—	82	123	—	15	—	1	5	8	1

See footnotes at end of Appendix table A.

APPENDIX TABLE A.—Number of person-years of observation and deaths from selected causes by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

	EX-SMOKERS WHO STOPPED FOR REASONS OTHER THAN "DR'S. ORDERS"—EX-SMOKERS OF PIPES AND CIGARS ONLY—TOTAL					
	Total 35–84	35–44	45–54	55–64	65–74	75–84
Person-years of observation:	14,063	343	280	6,683	6,271	486

Cause of death (underlying cause unless otherwise specified, International List Nos., 7th revision)	Mortality ratio	Annual probability of death × 10⁵*					Number of deaths					
		35–44	45–54	55–64	65–74	75–84	Total 35–84	35–44	45–54	55–64	65–74	75–84
All causes	1. 29	—	—	1, 147	3, 221	—	326	—	1	105	189	31
Cancer, all sites (140–205)	1. 26	—	—	192	551	—	56	—	—	18	33	5
Cancer of buccal cavity (140–144)	5. 18	—	—	—	30	—	2	—	—	—	2	—
Cancer of pharynx (145–148)	—	—	—	—	—	—	—	—	—	—	—	—
Cancer of esophagus (150)	—	—	—	—	—	—	—	—	—	—	—	—
Cancer of stomach (151)	1. 45	—	—	16	24	—	5	—	—	2	2	1
Cancer of intestines (152–153)	1. 12	—	—	24	94	—	8	—	—	3	5	—
Cancer of rectum (154)	. 30	—	—	—	15	—	1	—	—	—	1	—
Cancer of pancreas (157)	. 30	—	—	—	37	—	1	—	—	—	1	—
Cancer of larynx (161)	—	—	—	—	—	—	—	—	—	—	—	—
Cancer of lung and bronchus (162–163)	1. 43	—	—	10	39	—	4	—	—	1	3	—
Cancer of prostate (177)	2. 36	—	—	32	58	—	11	—	—	4	4	3
Cancer of kidney (180)	1. 44	—	—	10	—	—	2	—	—	1	—	1
Cancer of bladder and other (181)	2. 43	—	—	—	97	—	5	—	—	—	5	—
Malignant lymphoma (200, 201, 203)	. 93	—	—	10	51	—	4	—	—	1	3	—
Leukemia (204)	1. 51	—	—	16	24	—	4	—	—	2	2	—
All other sites (155–156, 158–160, 164–165, 170–176, 178–179, 190–199, 202, 205)	1. 08	—	—	75	83	—	9	—	—	4	5	—
Bronchitis and/or emphysema	—	—	—	—	—	—	—	—	—	—	—	—
Bronchitis (500–502)	—	—	—	—	—	—	—	—	—	—	—	—
Underlying or contributory	—	—	—	—	—	—	—	—	—	—	—	—
Emphysema without bronchitis (527.1)	—	—	—	—	—	—	—	—	—	—	—	—
Underlying or contributory	1. 49	—	—	34	55	—	4	—	—	1	2	1
Respiratory tuberculosis (001–008)	3. 30	—	—	22	12	—	2	—	—	1	1	—
Underlying or contributory	2. 17	—	—	22	26	—	3	—	—	1	2	—

Asthma (241)	6. 62	—	—	—	31	—	2	—	—	—	2	—
Underlying or contributory	1. 48	—	—	—	31	—	2	—	—	—	2	—
Influenza and pneumonia (480–493)	—	—	—	—	—	—	—	—	—	—	—	—
Underlying or contributory	1. 01	—	—	16	267	—	19	—	—	2	15	2
Other respiratory disease (470–475, 510–526, 527.0, 527.2)	1. 88	—	—	—	51	—	3	—	—	—	2	1
Underlying or contributory	1. 72	—	—	16	137	—	9	—	—	2	6	1
Total cardiovascular disease (330–334, 400–468)	1. 38	—	—	818	2, 259	—	230	—	1	77	129	23
Cerebral vascular lesions (330–334)	1. 31	—	—	117	320	—	31	—	—	10	18	3
Underlying or contributory	1. 41	—	—	191	537	—	52	—	—	18	29	5
Chronic rheumatic heart disease (410–416)	1. 29	—	—	10	73	—	4	—	—	1	3	—
Underlying or contributory	1. 32	—	—	27	91	—	7	—	—	3	4	—
Arteriosclerotic (coronary) heart disease (420)	1. 34	—	—	569	1, 378	—	145	—	—	53	79	13
Underlying or contributory	1. 33	—	—	671	1, 714	—	169	—	—	58	96	15
Nonrheumatic endocarditis, etc. (421–422)	2. 45	—	—	16	117	—	12	—	—	2	7	3
Underlying or contributory	2. 10	—	—	59	224	—	22	—	—	5	14	3
Other heart disease (430–434)	2. 36	—	—	16	84	—	8	—	1	2	5	—
Underlying or contributory	2. 05	—	—	56	518	—	35	—	1	6	26	2
Hypertension with heart disease (440–443)	1. 60	—	—	32	175	—	13	—	—	3	8	2
Underlying or contributory	1. 48	—	—	125	342	—	33	—	—	12	17	4
Hypertension without heart disease (444–447)	2. 29	—	—	16	12	—	4	—	—	2	1	1
Underlying or contributory	1. 58	—	—	54	12	—	8	—	—	6	1	1
General arteriosclerosis (450)	. 62	—	—	27	56	—	5	—	—	2	3	—
Underlying or contributory	. 74	—	—	65	210	—	20	—	—	6	11	3
Nonsyphilitic aneurysm of aorta (451)	1. 85	—	—	8	39	—	4	—	—	1	3	—
Other circulatory disease (400–402, 452–468)	1. 42	—	—	8	24	—	4	—	—	1	2	1
Chronic nephritis, etc. (592–594)	—	—	—	—	—	—	—	—	—	—	—	—
Underlying or contributory	. 78	—	—	22	12	—	2	—	—	1	1	—
Diabetes mellitus (260)	1. 81	—	—	22	24	—	3	—	—	1	2	—
Underlying or contributory	1. 55	—	—	69	288	—	21	—	—	5	15	1
Paralysis agitans (350)	1. 33	—	—	—	43	—	3	—	—	—	3	—
Underlying or contributory	. 85	—	—	—	55	—	4	—	—	—	4	—
Stomach ulcer (540)	2. 33	—	—	—	27	—	1	—	—	—	1	—
Underlying or contributory	1. 75	—	—	—	27	—	2	—	—	—	1	1
Duodenal ulcer (541)	3. 10	—	—	8	30	—	3	—	—	1	2	—
Underlying or contributory	3. 67	—	—	32	30	—	6	—	—	4	2	—
Cirrhosis of liver (581)	. 50	—	—	34	—	—	1	—	—	1	—	—
Other diseases of liver, etc. (580, 582, 587)	. 76	—	—	8	—	—	1	—	—	1	—	—
Violence (800–962, 970–991)	. 83	—	—	40	52	—	9	—	—	4	4	1
Ill-defined and unknown (780–795, XXX)†	. 52	—	—	—	49	—	4	—	—	—	4	—
All other	. 90	—	—	8	120	—	8	—	—	1	6	1

*Annual probabilities of death at each single year of age were combined into 10-year age groups by using weights proportional to the distribution of the U.S. male population in 1960. Not shown if less than 50 person-years of observation at any single year of age in the 10-year interval.

†Includes cases for which insurance death claims have been paid but death certificates have not yet been received.

APPENDIX TABLE B.—Number of person-years of observation and deaths from all causes, coronary heart disease, and lung cancer by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962

Smoking category and age		Mortality ratio			Annual probability of death × 10^5*			Person-years of observation	Number of deaths		
		All causes	CHD (420) †	Lung cancer (162–163)	All causes	CHD (420) †	Lung cancer (162–163)		All causes	CHD (420) †	Lung cancer (162–163)
Current smokers of cigarettes and other:											
Total	35–84	1. 51	1. 42	8. 98	—	—	—	260, 833	5, 517	2, 245	367
	55–64	—	—	—	1, 616	756	103	125, 810	2, 301	1, 033	148
	65–74	—	—	—	3, 641	1, 417	255	84, 785	2, 783	1, 073	200
	75–84	—	—	—	7, 389	2, 406	360	3, 902	266	83	13
Occasional	35–84	1. 22	1. 10	3. 77	—	—	—	21, 086	377	146	13
	55–64	—	—	—	1, 336	644	43	10, 227	138	64	5
	65–74	—	—	—	3, 025	1, 060	114	7, 179	209	73	8
	75–84	—	—	—	—	—	—	398	23	6	—
1–9/day	35–84	1. 17	1. 13	4. 07	—	—	—	47, 236	897	374	35
	55–64	—	—	—	1, 085	507	36	22, 980	311	139	9
	65–74	—	—	—	2, 985	1, 344	128	18, 956	512	214	22
	75–84	—	—	—	—	—	—	1, 054	63	21	4
10–20/day	35–84	1. 47	1. 40	7. 59	—	—	—	115, 843	2, 382	984	138
	55–64	—	—	—	1, 520	701	76	54, 218	950	438	44
	65–74	—	—	—	3, 584	1, 376	245	38, 457	1, 238	480	90
	75–84	—	—	—	—	—	—	1, 763	124	41	3
21–39/day	35–84	1. 90	1. 78	15. 98	—	—	—	66, 036	1, 536	625	145
	55–64	—	—	—	2, 052	984	186	32, 694	753	336	14
	65–74	—	—	—	4, 514	1, 629	463	17, 193	668	254	63
	75–84	—	—	—	—	—	—	574	47	12	4
Over 39/day	35–84	2. 31	1. 89	22. 99	—	—	—	10, 631	325	116	36
	55–64	—	—	—	2, 392	975	259	5, 691	149	56	16

	65–74	—	—	—	5, 522	2, 069	468	3, 001	156	52	17
	75–84	—	—	—	—	—	—	112	9	3	2
Current smokers of cigars only:											
<5/day	35–84	1. 04	1. 00	1. 14	—	—	—	56, 014	973	403	12
	55–64	—	—	—	941	351	4	26, 822	326	129	2
	65–74	—	—	—	2, 415	1, 016	47	23, 830	553	237	9
	75–84	—	—	—	—	—	—	1, 281	83	33	—
5–8/day	35–84	1. 17	1. 10	2. 64	—	—	—	21, 737	431	176	11
	55–64	—	—	—	1, 208	452	63	10, 951	151	59	6
	65–74	—	—	—	2, 957	1, 212	32	9, 380	251	106	4
	75–84	—	—	—	—	—	—	454	26	10	1
Over 8/day	35–84	1. 49	1. 18	2. 07	—	—	—	5, 162	128	44	2
	55–64	—	—	—	1, 743	792	—	2, 789	58	18	—
	65–74	—	—	—	—	—	—	2, 077	63	23	2
	75–84	—	—	—	—	—	—	104	6	3	—
Current smokers of pipes only:											
<5/day	35–84	. 93	. 89	. 77	—	—	—	14, 254	220	89	2
	55–64	—	—	—	1, 223	565	9	6, 280	79	36	1
	65–74	—	—	—	2, 193	854	27	5, 673	110	44	1
	75–84	—	—	—	—	—	—	484	28	9	—
5–19/day	35–84	1. 10	1. 17	2. 20	—	—	—	28, 813	545	247	12
	55–64	—	—	—	1, 095	526	29	13, 227	190	99	4
	65–74	—	—	—	2, 648	1, 093	73	12, 219	302	132	8
	75–84	—	—	—	—	—	—	892	48	15	—
Over 19/day	35–84	1. 20	1. 07	2. 47	—	—	—	6, 479	130	50	3
	55–64	—	—	—	1, 167	428	34	3, 258	49	20	2
	65–74	—	—	—	2, 853	924	26	2, 665	73	27	1
	75–84	—	—	—	—	—	—	147	6	2	—
Current smokers of pipes and cigars only: ≤8 Cigars and ≤19 pipes	35–84	1. 07	1. 04	1. 62	—	—	—	58, 616	1, 069	448	18
	55–64	—	—	—	1, 109	472	22	28, 349	364	153	6
	65–74	—	—	—	2, 743	1, 196	39	24, 369	604	258	9
	75–84	—	—	—	—	—	—	1, 789	90	35	3

See footnotes at end of Appendix table B.

APPENDIX TABLE B.—Number of person-years of observation and deaths from all causes, coronary heart disease, and lung cancer by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

Smoking category and age		Mortality ratio			Annual probability of death × 10^{5}*			Person-years of observation	Number of deaths		
		All causes	CHD (420) †	Lung cancer (162–163)	All causes	CHD (420) †	Lung cancer (162–163)		All causes	CHD (420) †	Lung cancer (162–163)
Over 8 cigars or over 19 pipes	35–84	1. 16	1. 17	2. 19	—	—	—	4, 871	94	41	2
	55–64	—	—	—	1, 093	365	23	2, 495	40	14	1
	65–74	—	—	—	—	—	—	1, 996	47	23	1
	75–84	—	—	—	—	—	—	109	5	3	—
Ex-smokers who stopped on "doctor's orders":											
Total	35–84	1. 92	2. 16	5. 83	—	—	—	40, 607	1, 269	623	44
	55–64	—	—	—	2, 053	1, 077	87	21, 174	506	262	19
	65–74	—	—	—	4, 570	2, 238	122	16, 632	695	334	21
	75–84	—	—	—	—	—	—	676	52	19	2
Ex-cigarette smokers	35–84	1. 95	2. 16	7. 05	—	—	—	33, 569	1, 038	503	43
	55–64	—	—	—	2, 040	1, 083	102	17, 921	429	220	19
	65–74	—	—	—	4, 560	2, 171	150	13, 221	552	261	20
	75–84	—	—	—	—	—	—	471	41	14	2
1–9/day	35–84	1. 78	1. 95	4. 42	—	—	—	3, 434	108	51	3
	55–64	—	—	—	—	—	—	1, 689	34	13	2
	65–74	—	—	—	—	—	—	1, 536	69	35	1
	75–84	—	—	—	—	—	—	98	4	2	—
10–20/day	35–84	1. 92	2. 21	9. 10	—	—	—	14, 860	461	231	25
	55–64	—	—	—	1, 905	1, 032	143	7, 802	175	91	11
	65–74	—	—	—	4, 473	2, 200	210	5, 993	257	127	11
	75–84	—	—	—	—	—	—	243	23	9	1
21–39/day	35–84	1. 87	1. 93	3. 96	—	—	—	11, 517	329	149	8
	55–64	—	—	—	1, 913	876	47	6, 325	150	70	5

	65–74	—	—	—	4, 300	1, 999	58	4, 281	160	75	2
	75–84	—	—	—	—	—	—	113	13	2	1
Over 39/day	35–84	2. 47	2. 87	10. 66	—	—	—	3, 759	140	72	7
	55–64	—	—	—	—	—	—	2, 105	70	46	1
	65–74	—	—	—	—	—	—	1, 411	66	24	6
	75–84	—	—	—	—	—	—	18	1	1	—
Ex-smokers who stopped for reasons other than "doctor's orders":											
Ex-smokers of cigarettes and other forms of tobacco, total	35–84	1. 19	1. 13	4. 43	—	—	—	137, 174	2, 570	1, 048	107
	55–64	—	—	—	1, 221	545	57	67, 998	961	422	41
	65–74	—	—	—	2, 933	1, 195	121	51, 904	1, 379	555	59
	75–84	—	—	—	7, 274	2, 234	205	2, 809	198	62	6
1–9/day	35–84	1. 03	. 98	1. 75	—	—	—	30, 095	534	218	10
	55–64	—	—	—	941	426	15	14, 447	169	76	4
	65–74	—	—	—	2, 626	1, 065	29	12, 692	298	120	4
	75–84	—	—	—	—	—	—	901	62	21	2
10–20/day	35–84	1. 13	1. 08	3. 47	—	—	—	66, 891	1, 190	491	41
	55–64	—	—	—	1, 184	507	51	32, 840	430	183	15
	65–74	—	—	—	2, 853	1, 231	117	25, 608	648	273	23
	75–84	—	—	—	—	—	—	1, 351	97	29	3
21–39/day	35–84	1. 41	1. 36	7. 12	—	—	—	30, 346	612	257	35
	55–64	—	—	—	1, 377	696	88	15, 662	259	127	14
	65–74	—	—	—	3, 331	1, 168	197	10, 097	312	118	19
	75–84	—	—	—	—	—	—	377	32	10	1
Over 39/day	35–84	1. 56	1. 26	12. 53	—	—	—	9, 842	234	82	21
	55–64	—	—	—	1, 756	656	123	5, 049	103	36	8
	65–74	—	—	—	3, 471	1, 449	273	3, 507	121	44	13
	75–84	—	—	—	—	—	—	180	7	2	—

See footnotes at end of Appendix table B.

Appendix table B.—Number of person-years of observation and deaths from all causes, coronary heart disease, and lung cancer by age, with age-specific annual probabilities of death and mortality ratios, according to smoking category. U.S. veterans study, July 1954–December 1962—Continued

Smoking category and age		Mortality ratio			Annual probability of death × 10⁵*			Person-years of observation	Number of deaths		
		All causes	CHD (420) †	Lung cancer (162–163)	All causes	CHD (420) †	Lung cancer (162–163)		All causes	CHD (420) †	Lung cancer (162–163)
Ex-smokers of cigars only:											
<5/day	35–84	1. 17	1. 38	. 67	—	—	—	14, 307	311	156	2
	55–64	—	—	—	1, 247	643	8	6, 405	93	49	1
	65–74	—	—	—	2, 812	1, 347	28	6, 856	182	87	1
	75–84	—	—	—	—	—	—	538	33	20	—
5–8/day	35–84	1. 21	1. 26	. 78	—	—	—	6, 269	142	63	1
	55–64	—	—	—	—	—	—	2, 928	48	23	—
	65–74	—	—	—	2, 598	1, 117	41	2, 897	74	29	1
	75–84	—	—	—	—	—	—	264	19	11	—
Over 8/day	35–84	1. 75	1. 81	2. 85	—	—	—	3, 438	110	49	2
	55–64	—	—	—	—	—	—	1, 739	43	23	—
	65–74	—	—	—	—	—	—	1, 541	54	22	2
	75–84	—	—	—	—	—	—	117	12	4	—
Ex-smokers of pipes only:											
<5/day	35–84	1. 18	1. 09	—	—	—	—	6, 335	122	48	—
	55–64	—	—	—	1, 051	452	—	2, 926	39	18	—
	65–74	—	—	—	3, 020	1, 219	—	2, 508	71	27	—
	75–84	—	—	—	—	—	—	182	9	2	—

5–19/day	35–84	1. 18	1. 29	3. 98	—	—	—	7, 949	159	75	6
	55–64	—	—	—	1, 184	653	—	3, 753	53	33	—
	65–74	—	—	—	2, 619	1, 078	166	3, 383	85	35	5
	75–84	—	—	—	—	—	—	218	18	6	1
Over 19/day	35–84	1. 44	1. 33	3. 58	—	—	—	1, 376	35	14	1
	55–64	—	—	—	—	—	—	622	20	10	—
	65–74	—	—	—	—	—	—	669	13	3	1
	75–84	—	—	—	—	—	—	29	2	1	—

*Annual probabilities of death at each single year of age were combined into 10-year age groups by using weights proportional to the distribution of the U.S. male population in 1960. Not shown if less than 50 person-years of observation at any single year of age in the 10-year interval.

†CHD: coronary heart disease. Figures in parentheses are International List Nos., 7th revision.

Appendix table C.—Mortality ratios and number of deaths from all causes by smoking category, respondent group, and time period. U.S. veterans study, July 1954–December 1962

Smoking category	Mortality ratio: 1954 Respondents			Mortality ratio: 1957 Respondents		Number of deaths: 1954 Respondents			Number of deaths: 1957 Respondents	
	7/54–6/57	7/57–12/60	1/61–12/62	7/57–12/60	1/61–12/62	7/54–6/57	7/57–12/60	1/61–12/62	7/57–12/60	1/61–12/62
Never smoked or occasional only	1. 00	1. 00	1. 00	1. 00	1. 00	1, 878	2, 490	1, 474	706	384
Current smokers—total	1. 44	1. 59	1. 67	1. 37	1. 61	4, 878	6, 991	4, 260	1, 913	1, 192
Current cigarette smokers—total	1. 59	1. 76	1. 86	1. 53	1. 81	3, 974	5, 675	3, 469	1, 564	962
Occasional cigarette	1. 09	1. 18	1. 42	1. 00	1. 01	125	178	125	52	29
1–9/day	1. 13	1. 36	1. 42	1. 28	1. 30	452	712	427	235	128
10–20/day	1. 60	1. 70	1. 76	1. 53	1. 85	1, 890	2, 601	1, 554	773	490
21–39/day	1. 85	2. 08	2. 22	1. 78	2. 21	1, 253	1, 815	1, 117	408	256
Over 39/day	2. 08	2. 40	2. 80	1. 94	2. 38	254	369	246	96	59
Current smokers of cigarettes only—total	1. 71	1. 89	1. 98	1. 73	1. 97	2, 576	3, 649	2, 210	1, 067	625
Occasional cigarette	1. 03	1. 23	1. 12	. 67	. 86	33	52	28	11	8
1–9/day	1. 31	1. 43	1. 53	1. 46	1. 59	254	359	221	142	81
10–20/day	1. 70	1. 84	1. 88	1. 70	1. 96	1, 264	1, 754	1, 040	544	324
21–39/day	1. 86	2. 13	2. 24	2. 04	2. 36	843	1, 237	754	304	175
Over 39/day	2. 20	2. 37	2. 80	1. 93	2. 13	182	247	167	66	37
Current smokers of cigarettes and other—total	1. 41	1. 57	1. 69	1. 23	1. 56	1, 398	2, 026	1, 259	497	337
Occasional cigarette	1. 12	1. 16	1. 54	1. 15	1. 08	92	126	97	41	21
1–9/day	. 96	1. 30	1. 31	1. 07	. 99	198	353	206	93	47
10–20/day	1. 43	1. 48	1. 55	1. 23	1. 67	626	847	514	229	166
21–39/day	1. 83	2. 00	2. 18	1. 29	1. 93	410	578	363	104	81
Over 39/day	1. 82	2. 46	2. 81	1. 96	2. 96	72	122	79	30	22
Current smokers of pipes and/or cigars only—total	1. 01	1. 12	1. 16	. 93	1. 11	904	1, 316	791	349	230
Current smokers of cigars only—total	. 95	1. 17	1. 20	1. 02	1. 07	353	571	341	169	98
<5/day	. 83	1. 10	1. 18	. 98	1. 11	209	365	228	105	66
5–8/day	1. 11	1. 23	1. 15	1. 17	1. 02	109	159	86	52	25
Over 8/day	1. 64	1. 71	1. 72	. 81	. 88	35	47	27	12	7
Current smokers of pipes only—total	1. 08	1. 11	1. 08	. 79	1. 13	247	333	186	72	57
<5/day	1. 01	. 96	. 94	. 64	. 79	65	81	45	17	12
5–19/day	1. 08	1. 13	1. 11	. 91	1. 20	147	199	113	50	36
Over 19/day	1. 18	1. 36	1. 21	. 50	1. 62	35	53	28	5	9
Current smokers of pipes and cigars only—total	1. 03	1. 06	1. 18	. 92	1. 16	304	412	264	108	75

≤ 8 cigars and ≤ 19 pipes/day	1.03	1.09	1.17	.87	1.04	281	391	241	94	62
Over 8 cigars or over 19 pipes/day	1.08	.75	1.37	1.40	2.54	23	21	23	14	13
Ex-smokers who stopped on "doctor's orders"—total	2.00	1.83	1.87	1.85	2.05	355	412	241	166	95
Ex-cigarette smokers—total	2.08	1.85	1.85	1.89	2.10	298	335	192	136	77
1–9/day	1.69	1.65	1.61	1.97	2.13	26	33	18	20	11
10–20/day	2.10	1.86	1.84	1.61	2.12	137	152	86	51	35
21–39/day	1.87	1.77	1.95	1.91	1.99	89	107	69	42	22
Over 39/day	3.03	2.30	1.77	2.74	2.25	46	43	19	23	9
Ex-smokers of cigarettes only—total	2.13	1.94	2.18	1.90	2.15	175	200	128	75	43
1–9/day	1.61	1.94	1.90	.92	2.73	11	17	9	4	6
10–20/day	2.15	1.85	2.22	1.50	1.82	77	84	57	25	16
21–39/day	1.74	1.96	2.35	2.18	2.29	51	72	50	29	15
Over 39/day	3.60	2.22	1.71	3.28	2.49	36	27	12	17	6
Ex-smokers who stopped for other reasons—total	1.22	1.25	1.35	1.19	1.33	1,669	2,229	1,401	836	501
Ex-cigarette smokers—total	1.22	1.26	1.37	1.18	1.35	1,360	1,842	1,169	657	403
1–9/day	1.00	1.06	1.20	1.05	1.04	229	321	210	135	72
10–20/day	1.20	1.15	1.34	1.12	1.24	642	810	554	287	172
21–39/day	1.39	1.54	1.48	1.34	1.73	361	519	294	158	108
Over 39/day	1.41	1.64	1.62	1.47	1.86	128	192	111	77	51
Ex-smokers of cigarettes only—total	1.27	1.37	1.40	1.27	1.45	702	993	591	358	217
1–9/day	1.07	1.20	1.00	1.23	1.15	101	149	72	74	37
10–20/day	1.27	1.23	1.43	1.15	1.33	329	422	286	147	91
21–39/day	1.39	1.65	1.49	1.48	1.67	199	310	164	97	58
Over 39/day	1.38	1.64	1.71	1.43	2.12	73	112	69	40	31
Ex-smokers of cigarettes and other—total	1.17	1.14	1.33	1.09	1.25	658	849	578	299	186
1–9/day	.95	.96	1.33	.90	.94	128	172	138	61	35
10–20/day	1.13	1.06	1.25	1.08	1.15	313	388	268	140	81
21–39/day	1.40	1.39	1.47	1.16	1.80	162	209	130	61	50
Over 39/day	1.44	1.64	1.49	1.51	1.55	55	80	42	37	20
Ex-smokers of pipes and/or cigars only—total	1.25	1.20	1.26	1.21	1.24	309	387	232	179	98
Ex-smokers of cigars only—total	1.38	1.16	1.35	1.14	1.04	156	170	113	83	41
< 5/day	1.35	1.00	1.33	.97	1.07	90	88	67	41	25
5–8/day	1.16	1.24	1.33	1.08	.86	35	48	29	21	9
Over 8/day	1.89	1.67	1.48	1.90	1.28	31	34	17	21	7
Ex-smokers of pipes only—total	1.24	1.23	1.03	1.10	1.38	84	110	53	41	28
< 5/day	1.11	1.22	.72	1.31	2.14	30	44	15	18	15
5–19/day	1.10	1.16	1.35	1.10	.95	38	53	35	22	11
Over 19/day	2.52	1.60	.62	.29	1.13	16	13	3	1	2
Ex-smokers of pipes or cigars only—total	1.04	1.24	1.36	1.46	1.51	69	107	66	55	29
≤ 8 cigars and ≤ 19 pipes/day	.93	1.26	1.43	1.44	1.57	52	92	59	47	26
Over 8 cigars or over 19 pipes/day	1.64	1.12	.96	1.60	1.14	17	15	7	8	3

APPENDIX TABLE D.—Number of person-years of observation and deaths from all causes, coronary heart disease, and lung cancer, with age-specific annual probabilities of death by age began cigarette smoking and years since cigarette smoking stopped, according to cigarette smoking categories (ages 55–64 and 65–74 only). U.S. veterans study, July 1954–December 1962

CIGARETTE SMOKERS—TOTAL

Age began cigarette smoking	Age 55–64						Age 65–74					
	Current smokers	Years since cigarette smoking stopped (excluding those who stopped because of "doctor's orders") §					Current smokers	Years since cigarette smoking stopped (excluding those who stopped because of "doctor's orders") §				
		Total†	1–4	5–9	10–14	15+		Total†	1–4	5–9	10–14	15+
	Person-years of observation											
Total‡	334, 175	139, 390	22, 086	34, 566	23, 682	58, 370	207, 895	102, 246	6, 195	24, 089	20, 056	51, 243
<15	25, 569	10, 735	1, 583	2, 558	1, 538	5, 050	16, 016	8, 600	434	1, 798	1, 470	4, 867
15–19	154, 204	58, 952	8, 572	14, 035	9, 850	26, 442	80, 043	38, 191	2, 046	8, 498	7, 408	20, 167
20–24	102, 910	45, 038	6, 690	10, 945	7, 738	19, 648	60, 703	29, 333	1, 796	6, 731	5, 615	15, 142
25+	49, 537	23, 513	5, 160	6, 919	4, 458	6, 949	49, 386	25, 078	1, 887	6, 932	5, 468	10, 766
	Observed number of deaths—all causes											
Total‡	6, 928	2, 131	379	596	365	779	7, 569	2, 887	173	766	637	1, 295
<15	665	201	39	41	40	81	736	265	11	67	51	134
15–19	3, 442	958	156	276	151	374	3, 072	1, 125	64	318	241	498
20–24	1, 964	645	114	177	116	237	2, 139	819	59	206	177	377
25+	814	306	68	101	55	81	1, 562	654	39	169	165	281
	Annual probability of death from all causes × 10^5*											
Total‡	1, 819	1, 340	1, 644	1, 501	1, 349	1, 132	4, 032	3, 126	—	—	3, 370	2, 778
<15	2, 311	1, 585	2, 287	1, 112	—	1, 444	5, 208	3, 402	—	—	3, 517	3, 003
15–19	1, 978	1, 455	1, 841	1, 742	1, 418	1, 177	4, 212	3, 259	—	—	3, 508	2, 777

20–24	1, 648	1, 253	1, 540	1, 555	1, 265	1, 061	3, 967	3, 093	—	—	3, 552	2, 694
25+	1, 368	1, 048	1, 253	1, 009	910	889	3, 487	2, 880	—	—	3, 025	2, 769
	Observed number of deaths—coronary heart disease (420)											
Total‡	3, 064	939	155	279	161	342	2, 943	1, 170	58	305	272	527
<15	275	90	13	19	19	39	266	101	3	28	17	53
15–19	1, 489	416	64	132	65	155	1, 180	451	19	119	101	210
20–24	885	298	48	85	56	109	817	333	23	88	78	144
25+	399	132	30	43	20	39	657	272	13	66	75	118
	Annual probability of death from coronary heart disease × 10⁵*											
Total‡	833	592	673	738	567	488	1, 559	1, 268	—	—	1, 433	1, 133
<15	967	739	872	478	—	724	1, 771	1, 273	—	—	1, 154	1, 180
15–19	880	630	725	864	503	497	1, 600	1, 314	—	—	1, 446	1, 186
20–24	791	572	650	794	666	445	1, 502	1, 224	—	—	1, 541	1, 000
25+	700	473	536	484	402	342	1, 486	1, 216	—	—	1, 423	1, 162
	Observed number of deaths from lung cancer (162–163)											
Total‡	528	94	34	32	12	16	537	119	14	41	29	34
<15	70	14	6	4	1	3	65	16	1	8	2	5
15–19	293	49	14	17	7	11	259	47	6	14	13	14
20–24	133	24	11	8	3	2	138	33	4	13	9	7
25+	30	7	3	3	1	—	70	20	3	6	5	6
	Annual probability of death from lung cancer × 10⁵*											
Total‡	138	71	155	104	57	18	281	128	—	—	183	67
<15	251	129	345	111	—	29	478	232	—	—	192	114
15–19	168	84	159	125	72	31	350	138	—	—	238	68
20–24	99	61	175	128	44	5	241	121	—	—	201	59
25+	53	28	63	26	10	—	162	85	—	—	101	50

See footnotes at end of Appendix table D.

Appendix table D.—Number of person-years of observation and deaths from all causes, coronary heart disease, and lung cancer, with age-specific annual probabilities of death by age began cigarette smoking and years since cigarette smoking stopped, according to cigarette smoking categories (ages 55–64 and 65–74 only). U.S. veterans study, July 1954–December 1962—Continued

CIGARETTE SMOKERS—MAXIMUM 1-9/DAY

Age began cigarette smoking	Age 55–64: Current smokers	Age 55–64: Years since cigarette smoking stopped (excluding those who stopped because of "doctor's orders") §: Total†	1–4	5–9	10–14	15+	Age 65–74: Current smokers	Age 65–74: Years since cigarette smoking stopped (excluding those who stopped because of "doctor's orders") §: Total†	1–4	5–9	10–14	15+
	Person-years of observation											
Total‡	33, 737	25, 221	2, 232	3, 964	3, 338	15, 462	28, 339	21, 978	815	3, 376	3, 116	14, 406
<15	1, 238	1, 375	80	161	103	1, 031	1, 149	1, 348	30	146	122	1, 037
15–19	10, 920	8, 632	598	1, 102	915	6, 002	7, 754	6, 571	174	870	843	4, 657
20–24	11, 981	9, 092	717	1, 398	1, 160	5, 810	8, 865	6, 805	258	1, 046	953	4, 521
25+	9, 272	5, 736	825	1, 274	1, 111	2, 508	10, 191	6, 853	348	1, 287	1, 158	4, 057
	Observed number of deaths—all causes											
Total‡	434	323	26	65	42	188	754	533	24	90	81	334
<15	14	23	2	4	1	16	44	31	—	2	4	24
15–19	154	111	9	17	14	71	214	157	7	23	26	100
20–24	153	111	3	21	14	73	226	173	9	31	22	111
25+	107	72	11	23	13	25	258	166	8	31	29	98
	Annual probability of death from all causes × 10^5*											
Total‡	1, 016	1, 054	1, 234	1, 352	984	972	2, 997	2, 701	—	—	2, 642	2, 655
<15	—	—	—	—	—	—	—	—	—	—	—	—
15–19	1, 108	1, 101	—	—	—	969	3, 062	2, 725	—	—	—	2, 562

20–24	1, 025	956	—	—	—	1, 034	2, 938	2, 816	—	—	—	2, 791
25+	934	959	—	—	—	—	2, 888	2, 642	—	—	2, 348	2, 690
	Observed number of deaths—coronary heart disease (420)											
Total‡	200	137	9	24	17	87	306	220	10	38	30	141
<15	5	12	1	2	—	9	15	12	—	1	2	9
15–19	66	50	5	6	7	32	90	62	1	7	11	43
20–24	61	48	—	8	6	34	92	70	4	15	4	47
25+	62	27	3	8	4	12	106	72	5	13	13	41
	Annual probability of death from coronary heart disease × 10^5*											
Total‡	472	432	557	504	357	408	1, 262	1, 105	—	—	1, 025	1, 091
<15	—	—	—	—	—	—	—	—	—	—	—	—
15–19	462	451	—	—	—	409	1, 285	1, 111	—	—	—	1, 099
20–24	400	405	—	—	—	426	1, 197	1, 064	—	—	—	1, 112
25+	587	357	—	—	—	—	1, 290	1, 124	—	—	1, 042	1, 082
	Observed number of deaths from lung cancer (162–163)											
Total‡	14	5	1	2	1	1	23	7	1	3	2	1
<15	1	—	—	—	—	—	2	—	—	—	—	—
15–19	5	2	—	1	—	1	7	1	—	—	—	1
20–24	6	1	1	—	—	—	8	5	1	2	2	—
25+	2	2	—	1	1	—	5	1	—	1	—	—
	Annual probability of death from lung cancer × 10^5*											
Total‡	29	11	42	30	15	3	86	30	—	—	49	6
<15	—	—	—	—	—	—	—	—	—	—	—	—
15–19	27	13	—	—	—	10	108	14	—	—	—	20
20–24	42	6	—	—	—	—	99	63	—	—	—	—
25+	15	18	—	—	—	—	52	15	—	—	—	—

See footnotes at end of Appendix table D.

APPENDIX TABLE D.—Number of person-years of observation and deaths from all causes, coronary heart disease, and lung cancer, with age-specific annual probabilities of death by age began cigarette smoking and years since cigarette smoking stopped, according to cigarette smoking categories (ages 55–64 and 65–74 only). U.S. veterans study, July 1954–December 1962—Continued

CIGARETTE SMOKERS—MAXIMUM 10-20/DAY

Age began cigarette smoking	Age 55–64						Age 65–74					
	Current smokers	Years since cigarette smoking stopped (excluding those who stopped because of "doctor's orders") §					Current smokers	Years since cigarette smoking stopped (excluding those who stopped because of "doctor's orders") §				
		Total†	1–4	5–9	10–14	15+		Total†	1–4	5–9	10–14	15+
	Person-years of observation											
Total‡	133, 626	65, 770	10, 341	16, 251	11, 386	27, 529	91, 856	49, 534	3, 074	11, 973	9, 928	24, 311
<15	8, 341	4, 628	639	1, 026	640	2, 318	6, 219	3, 924	172	791	688	2, 261
15–19	59, 631	28, 395	3, 918	6, 674	4, 954	12, 821	34, 799	19, 333	1, 011	4, 239	3, 772	10, 290
20–24	43, 827	21, 437	3, 240	5, 225	3, 745	9, 226	27, 611	14, 007	892	3, 300	2, 728	7, 075
25+	21, 284	10, 894	2, 517	3, 290	2, 023	3, 060	22, 626	11, 918	988	3, 600	2, 722	4, 600
	Observed number of deaths—all causes											
Total‡	2, 562	928	160	250	145	367	3, 187	1, 336	75	344	300	611
<15	190	73	15	11	12	35	235	114	5	25	18	65
15–19	1, 198	423	58	116	61	188	1, 231	536	26	148	107	254
20–24	814	297	58	83	51	105	963	362	29	86	86	161
25+	346	126	28	40	19	38	740	316	15	83	88	130
	Annual probability of death from all causes × 10⁵*											
Total‡	1, 637	1, 228	1, 497	1, 314	1, 043	1, 143	3, 813	3, 038	—	—	3, 235	2, 721
<15	1, 928	1, 235	—	—	—	—	4, 300	3, 337	—	—	—	3, 310
15–19	1, 723	1, 309	1, 482	1, 566	1, 033	1, 224	3, 871	3, 067	—	—	3, 050	2, 734

20–24	1, 595	1, 211	1, 700	1, 280	1, 215	1, 055	3, 910	2, 917	—	—	3, 663	2, 380
25+	1, 357	998	1, 109	—	—	—	3, 515	2, 994	—	—	3, 287	2, 886
	Observed number of deaths—coronary heart disease (420)											
Total‡	1, 176	410	62	122	77	148	1, 257	554	23	139	142	246
<15	87	37	5	7	7	18	77	40	1	8	7	24
15–19	544	178	24	54	33	67	488	223	9	59	51	103
20–24	382	139	22	44	28	45	365	155	11	33	45	66
25+	157	54	11	17	8	18	320	132	2	38	39	53
	Annual probability of death from coronary heart disease × 10⁵*											
Total‡	786	557	601	687	548	474	1, 483	1, 260	—	—	1, 482	1, 110
<15	936	730	—	—	—	—	1, 311	1, 184	—	—	—	1, 324
15–19	798	576	597	803	508	469	1, 501	1, 241	—	—	1, 364	1, 097
20–24	811	540	638	661	705	426	1, 478	1, 247	—	—	1, 834	973
25+	662	450	466	—	—	—	1, 511	1, 285	—	—	1, 496	1, 217
	Observed number of deaths from lung cancer (162–163)											
Total‡	157	32	10	11	1	10	201	43	5	10	11	17
<15	16	2	1	—	—	1	17	7	1	2	1	3
15–19	81	20	4	8	1	7	100	19	2	6	5	6
20–24	47	8	3	3	—	2	54	10	1	1	3	5
25+	13	2	2	—	—	—	29	7	1	1	2	3
	Annual probability of death from lung cancer × 10⁵*											
Total‡	96	49	104	87	5	24	239	109	—	—	155	69
<15	156	30	—	—	—	—	321	235	—	—	—	143
15–19	118	65	84	137	11	40	322	122	—	—	196	54
20–24	78	41	127	66	—	10	186	84	—	—	151	92
25+	43	35	114	—	—	—	152	78	—	—	91	56

See footnotes at end of Appendix table D.

Appendix table D.—Number of person-years of observation and deaths from all causes, coronary heart disease, and lung cancer, with age-specific annual probabilities of death by age began cigarette smoking and years since cigarette smoking stopped, according to cigarette smoking categories (ages 55–64 and 65–74 only). U.S. veterans study, July 1954–December 1962

CIGARETTE SMOKERS—MAXIMUM 21–39/DAY

Age began cigarette smoking	Age 55–64						Age 65–74					
	Current smokers	Years since cigarette smoking stopped (excluding those who stopped because of "doctor's orders") §					Current smokers	Years since cigarette smoking stopped (excluding those who stopped because of "doctor's orders") §				
		Total †	1–4	5–9	10–14	15+		Total †	1–4	5–9	10–14	15+
	Person-years of observation											
Total‡	107, 217	35, 929	7, 048	10, 560	6, 573	11, 578	55, 332	22, 417	1, 669	6, 346	5, 067	9, 228
<15	9, 594	3, 348	607	967	549	1, 223	5, 023	2, 366	168	618	482	1, 093
15–19	54, 118	16, 556	3, 044	4, 681	2, 969	5, 856	23, 811	9, 242	629	2, 495	2, 047	4, 051
20–24	30, 882	10, 742	2, 049	3, 190	2, 081	3, 414	15, 792	6, 128	475	1, 727	1, 377	2, 546
25+	12, 059	5, 023	1, 321	1, 690	957	1, 051	10, 363	4, 470	383	1, 456	1, 132	1, 487
	Observed number of deaths—all causes											
Total‡	2, 494	645	141	219	130	152	2, 263	713	59	237	177	237
<15	265	75	17	16	22	20	279	75	4	27	15	29
15–19	1, 342	324	67	117	56	84	1, 016	303	27	105	80	90
20–24	643	170	40	56	36	37	600	205	16	67	45	77
25+	232	72	17	30	15	10	354	124	12	37	36	39
	Annual probability of death from all causes $\times 10^5$*											
Total‡	2, 068	1, 621	1, 860	1, 897	1, 871	1, 158	4, 568	3, 469	—	—	3, 726	2, 808
<15	2, 531	1, 940	—	—	—	—	6, 230	—	—	—	—	—
15–19	2, 228	1, 784	2, 234	2, 090	1, 883	1, 224	4, 698	3, 569	—	—	4, 232	2, 461

20–24	1, 810	1, 533	1, 690	—	—	—	4, 326	3, 722	—	—	3, 662	3, 378
25+	1, 536	1, 052	1, 027	—	—	—	3, 864	3, 006	—	—	3, 196	—
	Observed number of deaths—coronary heart disease (420)											
Total‡	1, 081	301	64	106	53	77	858	285	21	92	72	98
<15	107	32	6	7	10	9	105	34	2	13	5	14
15–19	569	150	26	59	22	43	376	113	7	34	33	39
20–24	292	82	23	25	15	19	227	77	7	31	16	23
25+	111	36	9	15	6	6	146	56	5	13	17	21
	Annual probability of death from coronary heart disease × 10^5*											
Total‡	918	743	837	933	703	607	1, 695	1, 366	—	—	1, 558	1, 128
<15	983	804	—	—	—	—	2, 219	—	—	—	—	—
15–19	969	803	864	1, 038	605	630	1, 710	1, 382	—	—	1, 842	1, 078
20–24	872	757	1, 007	—	—	—	1, 573	1, 326	—	—	1, 334	971
25+	760	520	493	—	—	—	1, 580	1, 361	—	—	1, 653	—
	Observed number of deaths from lung cancer (162–163)											
Total‡	231	42	16	15	9	2	194	45	7	15	12	11
<15	32	8	4	2	1	1	30	4	—	3	—	1
15–19	133	25	10	8	6	1	89	18	4	2	6	6
20–24	55	6	1	3	2	—	49	14	2	8	3	1
25+	10	3	1	2	—	—	25	8	1	2	3	2
	Annual probability of death from lung cancer × 10^5*											
Total‡	187	138	230	169	182	9	411	208	—	—	268	142
<15	323	272	—	—	—	—	744	—	—	—	—	—
15–19	217	166	333	161	221	10	435	195	—	—	350	148
20–24	135	100	56	—	—	—	363	246	—	—	252	78
25+	58	37	35	—	—	—	282	176	—	—	278	—

See footnotes at end of Appendix table D.

APPENDIX TABLE D.—Number of person-years of observation and deaths from all causes, coronary heart disease, and lung cancer, with age-specific annual probabilities of death by age began cigarette smoking and years since cigarette smoking stopped, according to cigarette smoking categories (ages 55–64 and 65–74 only). U.S. veterans study, July 1954–December 1962—Continued

CIGARETTE SMOKERS—MAXIMUM OVER 39/DAY

Age began cigarette smoking	Age 55–64						Age 65–74					
	Current smokers	Years since cigarette smoking stopped (excluding those who stopped because of "doctor's orders")					Current smokers	Years since cigarette smoking stopped (excluding those who stopped because of "doctor's orders") §				
		Total†	1–4	5–9	10–14	15+		Total†	1–4	5–9	10–14	15+
	Person-years of observation											
Total‡	27, 905	12, 470	2, 464	3, 791	2, 384	3, 801	13, 297	8, 317	636	2, 395	1, 944	3, 298
<15	3, 440	1, 384	257	404	245	479	1, 941	962	64	243	178	476
15–19	14, 306	5, 370	1, 012	1, 577	1, 013	1, 763	5, 724	3, 046	231	894	747	1, 169
20–24	7, 097	3, 767	683	1, 133	753	1, 198	3, 287	2, 393	172	658	557	1, 000
25+	2, 991	1, 860	498	664	368	331	2, 273	1, 836	167	589	457	622
	Observed number of deaths—all causes											
Total‡	804	235	52	62	48	72	621	305	15	95	79	113
<15	119	30	5	10	5	10	89	45	2	13	14	16
15–19	436	100	22	26	20	31	288	129	4	42	28	54
20–24	184	67	13	17	15	22	165	79	5	22	24	28
25+	64	36	12	8	8	8	76	48	4	18	12	14
	Annual probability of death from all causes × 10⁵*											
Total‡	2, 686	1, 630	2, 064	1, 365	—	1, 623	5, 493	3, 883	—	—	4, 351	3, 535
<15	3, 159	—	—	—	—	—	—	—	—	—	—	—
15–19	2, 839	1, 722	2, 241	—	—	—	6, 158	4, 765	—	—	—	—

20–24	2, 409	1, 315	—	—	—	—	—	—	—	—	—	—
25+	2, 049	—	—	—	—	—	3, 689	—	—	—	—	—
Observed number of deaths—coronary heart disease (420)												
Total‡	337	91	20	27	14	30	223	111	4	36	28	42
<15	46	9	1	3	2	3	35	15	—	6	3	6
15–19	170	38	9	13	3	13	102	53	2	19	6	25
20–24	85	29	3	8	7	11	58	31	1	9	13	8
25+	36	15	7	3	2	3	28	12	1	2	6	3
Annual probability of death from coronary heart disease × 10⁵*												
Total‡	1, 193	646	674	665	—	562	1, 971	1, 482	—	—	1, 522	1, 433
<15	1, 302	—	—	—	—	—	—	—	—	—	—	—
15–19	1, 170	664	662	—	—	—	2, 139	2, 084	—	—	—	—
20–24	1, 223	574	—	—	—	—	—	—	—	—	—	—
25+	1, 103	—	—	—	—	—	1, 524	—	—	—	—	—
Observed number of deaths from lung cancer (162–163)												
Total‡	81	15	7	4	1	3	68	24	1	13	4	5
<15	15	4	1	2	—	1	12	5	—	3	1	1
15–19	49	2	—	—	—	2	32	9	—	6	2	1
20–24	14	9	6	2	1	—	16	4	—	2	1	1
25+	3	—	—	—	—	—	6	4	1	2	—	1
Annual probability of death from lung cancer × 10⁵*												
Total‡	286	90	240	78	—	61	558	300	—	—	357	124
<15	366	—	—	—	—	—	—	—	—	—	—	—
15–19	341	32	—	—	—	—	578	336	—	—	—	—
20–24	177	173	—	—	—	—	—	—	—	—	—	—
25+	182	—	—	—	—	—	296	—	—	—	—	—

See footnotes at end of Appendix table D.

Appendix table D.—Number of person-years of observation and deaths from all causes, coronary heart disease, and lung cancer, with age-specific annual probabilities of death by age began cigarette smoking and years since cigarette smoking stopped, according to cigarette smoking categories (ages 55–64 and 65–74 only). U.S. veterans study, July 1954–December 1962—Continued

SMOKERS OF CIGARETTES ONLY—TOTAL

Age began cigarette smoking	Age 55–64						Age 65–74					
	Current smokers	Years since cigarette smoking stopped (excluding those who stopped because of "doctor's orders") §					Current smokers	Years since cigarette smoking stopped (excluding those who stopped because of "doctor's orders") §				
		Total†	1–4	5–9	10–14	15+		Total†	1–4	5–9	10–14	15+
	Person-years of observation											
Total‡	208, 365	71, 392	12, 295	19, 083	12, 745	27, 016	123, 110	50, 342	3, 354	12, 795	10, 433	23, 515
<15	15, 567	5, 782	902	1, 452	848	2, 577	9, 302	4, 314	228	1, 014	807	2, 246
15–19	97, 467	30, 663	4, 929	7, 805	5, 261	12, 653	48, 164	19, 261	1, 121	4, 654	3, 961	9, 501
20–24	65, 445	23, 108	3, 743	6, 194	4, 350	8, 820	37, 655	14, 733	996	3, 615	2, 963	7, 147
25+	28, 990	11, 407	2, 692	3, 584	2, 254	2, 862	27, 243	11, 606	996	3, 442	2, 658	4, 495
	Observed number of deaths—all causes											
Total‡	4, 627	1, 170	231	355	215	364	4, 786	1, 508	101	445	355	597
<15	430	113	26	23	27	37	456	145	8	42	28	66
15–19	2, 326	542	98	168	85	191	1, 979	593	38	181	139	232
20–24	1, 334	347	63	109	71	104	1, 431	441	35	127	98	181
25+	515	157	42	54	30	31	889	315	20	90	89	116
	Annual probability of death from all causes × 10^5*											
Total‡	1, 942	1, 451	1, 769	1, 633	1, 472	1, 170	4, 313	3, 333	—	—	3, 659	2, 846
<15	2, 405	1, 699	—	—	—	1, 243	5, 436	3, 718	—	—	—	—
15–19	2, 116	1, 592	1, 906	1, 861	1, 461	1, 341	4, 521	3, 437	—	—	3, 809	2, 823

20–24	1, 734	1, 341	1, 547	1, 792	1, 443	934	4, 256	3, 267	—	—	3, 730	2, 694
25+	1, 509	1, 081	1, 407	—	—	—	3, 657	3, 069	—	—	3, 451	2, 768
	Observed number of deaths—coronary heart disease (420)											
Total‡	2, 031	517	93	162	95	165	1, 870	615	34	181	156	240
<15	174	49	7	10	14	18	182	50	2	18	7	23
15–19	989	237	39	82	36	80	748	236	11	72	58	93
20–24	604	162	29	49	34	50	543	183	12	46	49	76
25+	256	66	18	21	10	17	383	140	9	42	42	47
	Annual probability of death from coronary heart disease × 10^5*											
Total‡	880	636	713	763	622	517	1, 659	1, 342	—	—	1, 580	1, 119
<15	980	841	—	—	—	706	2, 065	1, 227	—	—	—	—
15–19	924	661	722	902	503	543	1, 680	1, 353	—	—	1, 558	1, 125
20–24	828	633	739	852	774	403	1, 567	1, 310	—	—	1, 806	1, 056
25+	783	477	563	—	—	—	1, 571	1, 364	—	—	1, 688	1, 083
	Observed number of deaths from lung cancer (162–163)											
Total‡	380	53	21	20	6	6	337	60	7	19	20	13
<15	50	9	5	2	—	2	37	7	1	3	1	2
15–19	214	25	9	10	3	3	165	28	5	6	9	8
20–24	95	14	4	6	3	1	98	19	1	9	7	2
25+	20	5	3	2	—	—	33	5	—	1	3	1
	Annual probability of death from lung cancer × 10^5*											
Total‡	158	83	180	118	38	14	300	135	—	—	258	55
<15	270	151	—	—	—	39	478	191	—	—	—	—
15–19	194	85	182	114	30	18	384	168	—	—	315	89
20–24	115	83	134	197	79	5	268	143	—	—	351	21
25+	68	48	121	—	—	—	141	55	—	—	131	15

See footnotes at end of Appendix table D.

APPENDIX TABLE D.—Number of person-years of observation and deaths from all causes, coronary heart disease, and lung cancer, with age-specific annual probabilities of death by age began cigarette smoking and years since cigarette smoking stopped, according to cigarette smoking categories (ages 55–64 and 65–74 only). U.S. veterans study, July 1954–December 1962—Continued

SMOKERS OF CIGARETTES ONLY—MAXIMUM 1-9/DAY

Age began cigarette smoking	Age 55–64						Age 65–74					
	Current smokers	Years since cigarette smoking stopped (excluding those who stopped because of "doctor's orders") §					Current smokers	Years since cigarette smoking stopped (excluding those who stopped because of "doctor's orders") §				
		Total†	1–4	5–9	10–14	15+		Total†	1–4	5–9	10–14	15+
	Person-years of observation											
Total‡	16, 448	10, 775	990	1, 868	1, 510	6, 341	13, 533	9, 286	371	1, 564	1, 455	5, 802
<15	472	704	31	70	52	552	534	584	11	58	48	455
15–19	4, 957	3, 563	235	467	411	2, 442	3, 394	2, 695	70	376	371	1, 868
20–24	6, 005	3, 924	348	687	541	2, 348	4, 400	2, 939	126	497	451	1, 864
25+	4, 877	2, 470	371	631	495	962	5, 081	2, 913	161	612	568	1, 568
	Observed number of deaths—all causes											
Total‡	210	154	13	34	19	88	375	235	13	54	27	138
<15	9	14	1	2	1	10	18	16	—	1	1	13
15–19	67	56	4	10	7	35	98	61	4	17	8	31
20–24	72	48	2	10	5	31	122	81	4	17	6	54
25+	59	35	5	12	6	12	132	73	5	17	12	39
	Annual probability of death from all causes × 10^5*											
Total‡	986	1, 206	—	—	—	1, 157	3, 130	2, 805	—	—	1, 853	2, 798
<15	—	—	—	—	—	—	—	—	—	—	—	—
15–19	1, 052	1, 417	—	—	—	1, 337	3, 112	2, 628	—	—	—	—

20–24	884	800	—	—	—	—	3, 199	2, 990	—	—	—	—
25+	983	—	—	—	—	—	3, 053	2, 734	—	—	—	—
	Observed number of deaths—coronary heart disease (420)											
Total‡	99	61	4	10	7	40	149	100	5	19	11	65
<15	4	7	1	1	—	5	6	7	—	1	—	6
15–19	27	22	2	3	3	14	42	24	1	5	3	15
20–24	30	20	—	2	3	15	47	33	1	5	2	25
25+	35	12	1	4	1	6	52	34	3	7	6	18
	Annual probability of death from coronary heart disease × 10⁵*											
Total‡	491	439	—	—	—	460	1, 242	1, 157	—	—	764	1, 248
<15	—	—	—	—	—	—	—	—	—	—	—	—
15–19	442	482	—	—	—	472	1, 309	1, 057	—	—	—	—
20–24	356	334	—	—	—	—	1, 109	1, 141	—	—	—	—
25+	652	—	—	—	—	—	1, 300	1, 230	—	—	—	—
	Observed number of deaths from lung cancer (162–163)											
Total‡	9	1	—	1	—	—	11	3	—	2	1	—
<15	—	—	—	—	—	—	1	—	—	—	—	—
15–19	3	—	—	—	—	—	2	—	—	—	—	—
20–24	4	—	—	—	—	—	5	3	—	2	1	—
25+	2	1	—	1	—	—	3	—	—	—	—	—
	Annual probability of death from lung cancer × 10⁵*											
Total‡	42	5	—	—	—	—	78	31	—	—	55	—
<15	—	—	—	—	—	—	—	—	—	—	—	—
15–19	37	—	—	—	—	—	60	—	—	—	—	—
20–24	61	—	—	—	—	—	92	99	—	—	—	—
25+	29	—	—	—	—	—	69	—	—	—	—	—

See footnotes at end of Appendix table D.

APPENDIX TABLE D.—Number of person-years of observation and deaths from all causes, coronary heart disease, and lung cancer, with age-specific annual probabilities of death by age began cigarette smoking and years since cigarette smoking stopped, according to cigarette smoking categories (ages 55–64 and 65–74 only). U.S. veterans study, July 1954–December 1962—Continued

SMOKERS OF CIGARETTES ONLY—MAXIMUM 10–20/DAY

Age began cigarette smoking	Age 55–64						Age 65–74					
	Current smokers	Years since cigarette smoking stopped (excluding those who stopped because of "doctor's orders") §					Current smokers	Years since cigarette smoking stopped (excluding those who stopped because of "doctor's orders") §				
		Total†	1–4	5–9	10–14	15+		Total†	1–4	5–9	10–14	15+
	Person-years of observation											
Total‡	81, 748	32, 930	5, 636	8, 722	5, 955	12, 531	54, 103	23, 926	1, 642	6, 187	4, 972	11, 036
<15	4, 729	2, 300	359	560	321	1, 060	3, 498	1, 887	94	457	370	967
15–19	36, 803	14, 500	2, 180	3, 632	2, 532	6, 151	20, 610	9, 523	542	2, 230	1, 923	4, 817
20–24	27, 619	10, 713	1, 775	2, 854	2, 052	4, 032	17, 236	6, 931	485	1, 737	1, 391	3, 305
25+	12, 367	5, 251	1, 310	1, 656	1, 034	1, 252	12, 546	5, 452	515	1, 743	1, 276	1, 917
	Observed number of deaths—all causes											
Total‡	1, 727	498	96	147	82	169	2, 018	688	42	202	170	271
<15	127	37	10	5	8	14	139	49	3	13	7	26
15–19	816	231	34	70	28	99	790	284	16	86	61	120
20–24	554	159	30	49	34	46	660	193	18	56	52	67
25+	222	63	21	23	10	9	422	156	5	45	49	57
	Annual probability of death from all causes × 10^5*											
Total‡	1, 800	1, 272	1, 566	1, 318	1, 080	1, 211	4, 078	3, 243	—	—	3, 644	2, 717
<15	2, 288	1, 415	—	—	—	—	4, 352	—	—	—	—	—
15–19	1, 911	1, 326	1, 375	1, 532	790	1, 428	4, 147	3, 242	—	—	3, 407	2, 753

20–24	1, 646	1, 286	1, 652	—	—	—	4, 289	3, 051	—	—	—	2, 158
25+	1, 590	940	—	—	—	—	3, 633	3, 386	—	—	3, 976	3, 070
	Observed number of deaths—coronary heart disease (420)											
Total‡	796	227	43	70	45	68	820	281	12	85	79	103
<15	59	19	4	3	5	7	54	12	—	4	3	5
15–19	369	102	15	34	16	37	318	114	4	34	28	47
20–24	262	80	15	26	19	20	256	84	7	20	27	30
25+	103	24	9	7	4	4	189	69	1	26	21	21
	Annual probability of death from coronary heart disease × 10[5]*											
Total‡	872	607	723	635	654	510	1, 641	1, 288	—	—	1, 595	990
<15	1, 125	960	—	—	—	—	1, 681	—	—	—	—	—
15–19	881	599	555	769	494	535	1, 630	1, 232	—	—	1, 477	1, 010
20–24	849	631	876	—	—	—	1, 669	1, 272	—	—	—	893
25+	821	411	—	—	—	—	1, 604	1, 491	—	—	1, 695	1, 095
	Observed number of deaths from lung cancer (162–163)											
Total‡	117	17	5	6	1	5	117	20	3	4	6	7
<15	11	1	—	—	—	1	6	2	1	—	—	1
15–19	60	10	2	4	1	3	56	11	2	3	3	3
20–24	37	4	1	2	—	1	38	5	—	1	2	2
25+	9	2	2	—	—	—	16	2	—	—	1	1
	Annual probability of death from lung cancer × 10[5]*											
Total‡	119	48	106	59	9	26	241	98	—	—	183	55
<15	173	24	—	—	—	—	221	—	—	—	—	—
15–19	145	51	81	70	22	37	313	138	—	—	232	65
20–24	99	45	87	—	—	—	221	71	—	—	—	44
25+	50	70	—	—	—	—	152	68	—	—	117	35

See footnotes at end of Appendix table D.

781-871—65——9

APPENDIX TABLE D.—Number of person-years of observation and deaths from all causes, coronary heart disease, and lung cancer, with age-specific annual probabilities of death by age began cigarette smoking and years since cigarette smoking stopped, according to cigarette smoking categories (ages 55–64 and 65–74 only). U.S. veterans study, July 1954–December 1962—Continued

SMOKERS OF CIGARETTES ONLY—MAXIMUM 21–39/DAY

Age began cigarette smoking	Age 55–64						Age 65–74					
	Current smokers	Years since cigarette smoking stopped (excluding those who stopped because of "doctor's orders") §					Current smokers	Years since cigarette smoking stopped (excluding those who stopped because of "doctor's orders") §				
		Total†	1–4	5–9	10–14	15+		Total†	1–4	5–9	10–14	15+
	Person-years of observation											
Total‡	68, 484	20, 267	4, 132	6, 161	3, 844	6, 033	33, 631	12, 320	960	3, 614	2, 872	4, 829
<15	5, 993	1, 929	346	572	328	681	2, 858	1, 286	87	351	278	563
15–19	34, 880	9, 415	1, 866	2, 737	1, 706	3, 107	14, 789	5, 302	368	1, 507	1, 240	2, 187
20–24	20, 252	6, 118	1, 189	1, 915	1, 274	1, 740	10, 165	3, 385	280	974	759	1, 372
25+	7, 073	2, 679	723	931	533	488	5, 613	2, 239	218	756	579	675
	Observed number of deaths—all causes											
Total‡	1, 663	386	92	134	80	79	1, 454	401	37	135	109	119
<15	169	45	11	9	14	11	174	48	4	19	10	15
15–19	892	192	45	70	33	44	676	171	15	57	50	49
20–24	447	106	26	40	23	17	399	118	9	41	26	42
25+	150	42	10	15	10	7	199	62	9	17	23	13
	Annual probability of death from all causes × 10^5*											
Total‡	2, 154	1, 798	2, 049	2, 205	1, 998	1, 114	4, 846	3, 592	—	—	4, 147	2, 759
<15	2, 476	2, 044	—	—	—	—	—	—	—	—	—	—
15–19	2, 315	1, 956	2, 395	2, 264	—	1, 194	5, 190	3, 685	—	—	—	—

20–24	1, 928	1, 759	1, 910	—	—	—	4, 322	3, 810	—	—	—	—
25+	1, 615	1, 188	—	—	—	—	4, 121	3, 009	—	—	—	—
Observed number of deaths—coronary heart disease (420)												
Total‡	708	174	35	63	32	43	542	167	15	54	52	45
<15	66	19	2	4	7	6	75	21	2	9	3	7
15–19	369	88	16	35	14	23	233	68	5	22	23	18
20–24	201	44	13	16	7	8	147	45	4	15	13	13
25+	71	22	4	8	4	6	85	31	4	7	13	7
Annual probability of death from coronary heart disease × 10⁵*												
Total‡	939	776	790	1, 042	700	629	1, 739	1, 551	—	—	2, 060	1, 054
<15	947	854	—	—	—	—	—	—	—	—	—	—
15–19	989	814	911	1, 020	—	645	1, 748	1, 565	—	—	—	—
20–24	896	780	933	—	—	—	1, 474	1, 462	—	—	—	—
25+	785	637	—	—	—	—	1, 715	1, 598	—	—	—	—
Observed number of deaths from lung cancer (162–163)												
Total‡	157	28	13	11	4	—	129	26	4	7	9	6
<15	23	5	4	1	—	—	17	2	—	1	—	1
15–19	91	15	7	6	2	—	65	13	3	1	4	5
20–24	36	6	1	3	2	—	37	9	1	5	3	—
25+	7	2	1	1	—	—	9	2	—	—	2	—
Annual probability of death from lung cancer × 10⁵*												
Total‡	198	176	315	247	98	—	441	219	—	—	369	147
<15	304	298	—	—	—	—	—	—	—	—	—	—
15–19	234	194	390	229	—	—	533	240	—	—	—	—
20–24	140	168	96	—	—	—	384	304	—	—	—	—
25+	75	50	—	—	—	—	207	84	—	—	—	—

See footnotes at end of Appendix table D.

APPENDIX TABLE D.—Number of person-years of observation and deaths from all causes, coronary heart disease, and lung cancer, with age-specific annual probabilities of death by age began cigarette smoking and years since cigarette smoking stopped, according to cigarette smoking categories (ages 55–64 and 65–74 only). U.S. veterans study, July 1954–December 1962—Continued

SMOKERS OF CIGARETTES ONLY—MAXIMUM OVER 39/DAY

Age began cigarette smoking	Age 55–64						Age 65–74					
	Current smokers	Years since cigarette smoking stopped (excluding those who stopped because of "doctor's orders") §					Current smokers	Years since cigarette smoking stopped (excluding those who stopped because of "doctor's orders") §				
		Total†	1–4	5–9	10–14	15+		Total†	1–4	5–9	10–14	15+
	Person-years of observation											
Total‡	18, 064	7, 421	1, 537	2, 331	1, 436	2, 111	8, 014	4, 810	382	1, 429	1, 134	1, 848
<15	2, 215	849	166	250	148	284	1, 167	556	35	149	110	262
15–19	9, 423	3, 185	648	971	612	953	3, 507	1, 741	142	541	427	629
20–24	4, 556	2, 352	431	738	483	699	2, 005	1, 477	104	406	361	606
25+	1, 824	1, 007	288	367	193	160	1, 300	1, 002	102	331	235	335
	Observed number of deaths—all causes											
Total‡	546	132	30	40	34	28	366	184	9	54	49	69
<15	71	17	4	7	4	2	60	32	1	9	10	12
15–19	306	63	15	18	17	13	166	77	3	21	20	32
20–24	132	34	5	10	9	10	103	49	4	13	14	18
25+	37	17	6	4	4	3	35	24	1	11	5	7
	Annual probability of death from all causes $\times 10^5$*											
Total‡	2, 791	1, 545	1, 900	1, 417	—	—	5, 631	4, 192	—	—	—	—
<15	2, 885	—	—	—	—	—	—	—	—	—	—	—
15–19	2, 931	1, 832	—	—	—	—	—	—	—	—	—	—
20–24	2, 756	—	—	—	—	—	—	—	—	—	—	—
25+	2, 258	—	—	—	—	—	—	—	—	—	—	—

	Observed number of deaths—coronary heart disease (420)												
Total‡	222	55	11	19	11	14	132	67	2	23	14	27
<15	24	4	—	2	2	—	22	10	—	4	1	5
15–19	115	25	6	10	3	6	60	30	1	11	4	13
20–24	62	18	1	5	5	7	36	21	—	6	7	8
25+	21	8	4	2	1	1	14	6	1	2	2	1
	Annual probability of death from coronary heart disease × 10⁵*												
Total‡	1, 178	640	543	844	—	—	1, 976	1, 496	—	—	—	—
<15	1, 017	—	—	—	—	—	—	—	—	—	—	—
15–19	1, 117	686	—	—	—	—	—	—	—	—	—	—
20–24	1, 429	—	—	—	—	—	—	—	—	—	—	—
25+	1, 210	—	—	—	—	—	—	—	—	—	—	—
	Observed number of deaths from lung cancer (162–163)												
Total‡	59	7	3	2	1	1	42	11	—	6	4	—
<15	12	3	1	1	—	1	10	3	—	2	1	—
15–19	37	—	—	—	—	—	18	4	—	2	2	—
20–24	9	4	2	1	1	—	10	2	—	1	1	—
25+	1	—	—	—	—	—	2	1	—	1	—	—
	Annual probability of death from lung cancer × 10⁵*												
Total‡	315	68	182	60	—	—	644	327	—	—	—	—
<15	477	—	—	—	—	—	—	—	—	—	—	—
15–19	359	—	—	—	—	—	—	—	—	—	—	—
20–24	192	—	—	—	—	—	—	—	—	—	—	—
25+	225	—	—	—	—	—	—	—	—	—	—	—

*Annual probabilities of death at each single year of age were combined into 10-year age groups by using weights proportional to the distribution of the U.S. male population in 1960. Not shown if less than 50 person-years of observation at any single year of age in the 10-year interval.

†Includes unknown number of years since stopped.

‡Includes unknown age began.

§With the passage of each calendar year since the original report, the number of years since stopped was increased by 1.

APPENDIX E

VETERANS ADMINISTRATION

WASHINGTON 25, D. C.

This is an appeal to you to cooperate in a scientific study which will almost certainly yield results of great importance to medicine and public health.

The rapid increase in the use of tobacco in recent years has caused much discussion in medical circles concerning the possible effects of tobacco on health. The evidence presently available in regard to the subject does not clearly establish whether or not the use of tobacco is a serious hazard except for persons with certain diseases. It is necessary to gather the data from a large number of persons in order to obtain a dependable answer.

Consequently the Veterans Administration is cooperating with the United States Public Health Service in a study of this question by distributing the enclosed questionnaire.

Only a few minutes of your time will be required to complete it and an envelop which requires no postage is enclosed for your convenience in returning your questionnaire. I know you will feel a sense of personal satisfaction in helping the government make this valuable research study.

With many thanks for your cooperation, I am

Sincerely yours,

Administrator of Veterans' Affairs

PLEASE ANSWER EACH OF THE FOLLOWING QUESTIONS WHICH APPLIES TO YOU. IF YOU DO NOT REMEMBER EXACTLY, ENTER YOUR BEST ESTIMATE.

DATE

1. DATE OF YOUR BIRTH *(Day, Month, Year)*

2. USUAL OCCUPATION *(Please answer even if you no longer work.)*

WHAT KIND OF WORK HAVE YOU DONE DURING MOST OF YOUR LIFE? *(for example carpenter, punchpress operator, sales clerk, proprietor)*

WHAT KIND OF BUSINESS OR INDUSTRY WAS YOUR EMPLOYER ENGAGED IN? *(for example, housing construction, auto factory, radio retail, hardware store)*

HOW MANY YEARS DID YOU DO THIS KIND OF WORK? *(not necessarily with the same employer)*	NUMBER YEARS

3A. HAVE YOU EVER USED TOBACCO IN ANY FORM? ☐ YES ☐ NO

B. IF YOU ARE STILL USING TOBACCO, HOW MANY YEARS ALTOGETHER HAVE YOU USED IT? *YEARS*

C. IF YOU HAVE STOPPED USING TOBACCO, HOW MANY YEARS ALTOGETHER DID YOU USE IT? *YEARS*

D. DURING YOUR ENTIRE LIFE HAVE YOU EVER:	YES	NO
SMOKED AT LEAST AS MANY AS 5 TO 10 PACKS OF CIGARETTES?		
SMOKED AT LEAST AS MANY AS 50 TO 75 CIGARS?		
SMOKED AT LEAST AS MANY AS 3 TO 5 PACKAGES OF PIPE TOBACCO?		
CHEWED AT LEAST AS MANY AS 3 TO 5 PACKAGES OR PLUGS OF CHEWING TOBACCO?		
REGULARLY USED SNUFF FOR AT LEAST SIX MONTHS?		

If your answer to ANY of the five questions in Item 3D above is "YES," please answer the following questions about that form of tobacco. If your answer to all of the five questions in Item 3D above is "NO," please return the questionnaire without answering the following questions.

C I G A R E T T E S

4. AT THE PRESENT TIME, HOW MANY CIGARETTES DO YOU SMOKE ON THE AVERAGE?	CHECK ONE	HOW MANY YEARS HAVE YOU SMOKED AT THIS RATE?
1 NONE		
2 SMOKED CIGARETTES ONCE IN AWHILE BUT NOT EVERY DAY		
3 REGULARLY SMOKE CIGARETTES BUT LESS THAN 10 A DAY		
4 REGULARLY SMOKE FROM 10 TO 20 CIGARETTES A DAY		
5 REGULARLY SMOKE MORE THAN 20 BUT LESS THAN 40 CIGARETTES A DAY		
6 REGULARLY SMOKE 40 OR MORE CIGARETTES A DAY		

5. HOW OLD WERE YOU WHEN YOU STARTED TO SMOKE CIGARETTES?

6. IF YOU SMOKE CIGARETTES NOW, HOW LONG HAVE YOU BEEN SMOKING THEM? *YEARS*

7A. IF YOU DO *NOT* SMOKE CIGARETTES NOW, HOW LONG HAS IT BEEN SINCE YOU LAST SMOKED THEM? *YEARS*

B. HOW MANY YEARS DID YOU SMOKE CIGARETTES?

C. WHY DID YOU STOP?

8. HAVE YOU EVER REGULARLY SMOKED MORE CIGARETTES PER DAY THAN YOU DO NOW? ☐ YES ☐ NO

IF *YES*, CHECK THE *MAXIMUM* NUMBER OF CIGARETTES EVER REGULARLY SMOKED AND NUMBER YEARS SMOKED AT THAT RATE:

AVERAGE NUMBER OF CIGARETTES	CHECK ONE	ENTER NO. YRS
1 SMOKED CIGARETTES ONCE IN AWHILE BUT NOT EVERY DAY		
2 REGULARLY SMOKED LESS THAN 10 CIGARETTES A DAY		
3 REGULARLY SMOKED FROM 10 TO 20 CIGARETTES A DAY		
4 REGULARLY SMOKED MORE THAN 20 BUT LESS THAN 40 CIGARETTES A DAY		
5 REGULARLY SMOKED 40 OR MORE CIGARETTES A DAY		

(OVER)

CIGARS

9. AT THE PRESENT TIME, HOW MANY CIGARS DO YOU SMOKE ON THE AVERAGE?	CHECK ONE	HOW MANY YEARS HAVE YOU SMOKED AT THIS RATE?
1 NONE		X
2 SMOKE CIGARS ONCE IN AWHILE BUT NOT EVERY DAY		
3 REGULARLY SMOKE 1 OR 2 CIGARS A DAY		
4 REGULARLY SMOKE 3 OR 4 CIGARS A DAY		
5 REGULARLY SMOKE 5 TO 8 CIGARS A DAY		
6 REGULARLY SMOKE 9 OR MORE CIGARS A DAY		

10. HOW OLD WERE YOU WHEN YOU STARTED TO SMOKE CIGARS? _____ *YEARS*

11. IF YOU SMOKE CIGARS NOW, HOW LONG HAVE YOU BEEN SMOKING THEM? _____ *YEARS*

12A. IF YOU DO *NOT* SMOKE CIGARS NOW, HOW LONG HAS IT BEEN SINCE YOU LAST SMOKED THEM? _____ *YEARS*

B. HOW MANY YEARS DID YOU SMOKE CIGARS?

C. WHY DID YOU STOP?

13. HAVE YOU EVER REGULARLY SMOKED MORE CIGARS PER DAY THAN YOU DO NOW? ☐ YES ☐ NO

IF *YES*, CHECK THE *MAXIMUM* NUMBER OF CIGARS EVER REGULARLY SMOKED AND NUMBER YEARS SMOKED AT THAT RATE:

AVERAGE NUMBER OF CIGARS	CHECK ONE	ENTER NO. YRS.
1 SMOKED CIGARS ONCE IN AWHILE BUT NOT EVERY DAY		
2 REGULARLY SMOKED 1 OR 2 CIGARS A DAY		
3 REGULARLY SMOKED 3 OR 4 CIGARS A DAY		
4 REGULARLY SMOKED 5 TO 8 CIGARS A DAY		
5 REGULARLY SMOKED 9 OR MORE CIGARS A DAY		

PIPE SMOKING

14. AT THE PRESENT TIME, HOW MUCH PIPE SMOKING ARE YOU DOING ON THE AVERAGE?	CHECK ONE	HOW MANY YEARS HAVE YOU SMOKED AT THIS RATE?
1 NONE		X
2 SMOKE A PIPE ONCE IN AWHILE BUT NOT EVERY DAY		
3 REGULARLY SMOKE A PIPE BUT LESS THAN 5 PIPEFULS A DAY		
4 REGULARLY SMOKE FROM 5 TO 9 PIPEFULS A DAY		
5 REGULARLY SMOKE FROM 10 TO 19 PIPEFULS A DAY		
6 REGULARLY SMOKE 20 OR MORE PIPEFULS A DAY		

15. HOW OLD WERE YOU WHEN YOU STARTED TO SMOKE A PIPE? _____ *YEARS*

16. IF YOU SMOKE A PIPE NOW, HOW LONG HAVE YOU BEEN SMOKING ONE? _____ *YEARS*

17A. IF YOU DO *NOT* SMOKE A PIPE NOW, HOW LONG HAS IT BEEN SINCE YOU LAST SMOKED ONE? _____ *YEARS*

B. HOW MANY YEARS DID YOU SMOKE A PIPE?

C. WHY DID YOU STOP?

18. HAVE YOU EVER REGULARLY SMOKED A PIPE MORE THAN YOU DO NOW? ☐ YES ☐ NO

IF *YES*, CHECK THE *MAXIMUM* AMOUNT OF PIPE SMOKING YOU HAVE EVER DONE REGULARLY AND NUMBER YEARS AT THAT RATE:

AVERAGE AMOUNT OF PIPE SMOKING	CHECK ONE	ENTER NO. YRS.
1 SMOKED A PIPE ONCE IN AWHILE BUT NOT EVERY DAY		
2 REGULARLY SMOKED LESS THAN 5 PIPEFULS A DAY		
3 REGULARLY SMOKED FROM 5 TO 9 PIPEFULS A DAY		
4 REGULARLY SMOKED FROM 10 TO 19 PIPEFULS A DAY		
5 REGULARLY SMOKED 20 OR MORE PIPEFULS A DAY		

USE OF CHEWING TOBACCO AND SNUFF

19. AT THE PRESENT TIME, HOW MUCH TOBACCO DO YOU CHEW OR USE AS SNUFF, ON THE AVERAGE?	CHECK ONE	HOW MANY YEARS HAVE YOU USED TOBACCO AT THIS RATE?
1 NONE		X
2 CHEW TOBACCO OR USE SNUFF ONCE IN AWHILE BUT NOT EVERY DAY		
3 REGULARLY CHEW TOBACCO OR USE SNUFF PRACTICALLY EVERY DAY		

20. HOW OLD WERE YOU WHEN YOU STARTED TO CHEW TOBACCO OR USE SNUFF? _____ *YEARS*

21. IF YOU CHEW TOBACCO OR USE SNUFF NOW, HOW LONG HAVE YOU BEEN DOING THIS? _____ *YEARS*

22A. IF YOU DO *NOT* CHEW TOBACCO OR USE SNUFF NOW, HOW LONG HAS IT BEEN SINCE YOU LAST DID SO? _____ *YEARS*

B. HOW MANY YEARS DID YOU CHEW TOBACCO OR USE SNUFF?

C. WHY DID YOU STOP?

23. HAVE YOU EVER REGULARLY CHEWED MORE TOBACCO OR USED MORE SNUFF THAN YOU DO NOW? ☐ YES ☐ NO

IF *YES*, CHECK THE *MAXIMUM* AMOUNT OF CHEWING TOBACCO OR SNUFF YOU HAVE EVER USED REGULARLY, AND NUMBER OF YEARS YOU USED TOBACCO AT THIS RATE:

AVERAGE AMOUNT OF TOBACCO USED.	CHECK ONE	ENTER NO. YRS.
CHEWED TOBACCO OR USED SNUFF ONCE IN AWHILE BUT NOT EVERY DAY		
REGULARLY CHEWED TOBACCO OR USED SNUFF PRACTICALLY EVERY DAY		

Smoking in Relation to the Death Rates of One Million Men and Women [1]

E. Cuyler Hammond, *Statistical Research Section, Medical Affairs Department, American Cancer Society, Inc., New York, New York*

A large number of men and women were enrolled in a prospective study in late 1959 and early 1960 and have now been traced 4 times at annual intervals (*1*). Their physical complaints, smoking habits, and the relationship between these habits and complaints have been reported (*2–5*). After 3 years of follow-up, a report was made on morbidity and mortality in relation to the smoking habits of the male subjects (*6*). This paper includes data on both sexes. Particular attention is given to a comparison of men and women with respect to the degree of association between smoking and death rates. The paper is divided into five parts: introduction, a description of the material and methods, findings on total death rates (*i.e.*, death rates from all causes combined), findings on various specific causes of death, and an Appendix providing additional details.

More men than women smoke (*3*, *4*). The difference is considerable among people of early middle age and even greater among older people. Furthermore, female smokers (as a total group) are not comparable to male smokers with respect to type or amount of smoking. With few exceptions, American women smoke only cigarettes while men can be subclassified into several categories: cigarettes only; pipes only; cigars only; cigarettes and pipes; cigarettes and cigars; pipes and cigars; and all three (cigarettes, pipes, and cigars). Men and women who smoke only cigarettes, while comparable in form of tobacco use, differ in amount smoked. This is illustrated in table 1 which is confined to subjects currently smoking cigarettes at the time they enrolled in the study (the men representing persons with a lifetime history of only cigarette smoking). Men, as a group, smoked more cigarettes per day than women, inhaled the smoke to a greater degree, and started smoking cigarettes earlier in life.

Even men and women who use the same number of cigarettes a day are not comparable in their smoking habits. Within each of 4 levels of current amount of cigarette smoking per day (1–9, 10–19, 20–39, and

[1] This study was made possible by the cooperation of the subjects, volunteer workers of the American Cancer Society, Inc., staff members of 29 Divisions and many county units of the American Cancer Society, Inc., State health departments supplying copies of death certificates, and many physicians who furnished information on diagnosis of causes of death. Lawrence Garfinkel was of great assistance in analyzing the data. John Irwin, with the assistance of Henry Vasquez, carried out the computer work. Alan Horn supervised the coding of questionnaires and follow-up records. Herbert Johnson coded death certificates and carried out many of the computations.

TABLE 1.—Percentage distribution of current cigarette smokers by amount of smoking, degree of inhalation, and age at start of smoking. Men compared with women in 3 age groups. Table confined to current cigarette smokers with history of only cigarette smoking

Amount, inhalation, and age at start of cigarette smoking	Age 35–44 Men (%)	Age 35–44 Women (%)	Age 55–64 Men (%)	Age 55–64 Women (%)	Age 75–84 Men (%)	Age 75–84 Women (%)
Number per day:						
1–9	6. 8	22. 8	10. 0	30. 1	30. 1	47. 3
10–19	15. 7	30. 4	20. 6	31. 2	30. 4	30. 2
20–39	63. 6	43. 2	58. 3	35. 9	36. 8	21. 9
40+	13. 9	3. 6	11. 1	2. 8	2. 7	0. 6
Total	100. 0	100. 0	100. 0	100. 0	100. 0	100. 0
Inhalation:						
None	3. 0	7. 0	8. 4	25. 9	23. 4	51. 1
Slight	10. 3	19. 9	16. 9	28. 6	28. 4	27. 4
Moderate	56. 5	57. 7	53. 9	38. 3	35. 4	17. 5
Deep	30. 2	15. 4	20. 8	7. 2	12. 8	4. 0
Total	100. 0	100. 0	100. 0	100. 0	100. 0	100. 0
Age at start:						
30+	1. 4	8. 7	5. 6	51. 3	21. 2	85. 5
25–29	3. 6	8. 8	5. 4	20. 0	5. 9	5. 0
20–24	21. 7	27. 5	24. 8	18. 0	20. 0	4. 7
15–19	60. 5	50. 8	51. 7	9. 9	37. 6	3. 2
<15	12. 8	4. 2	12. 5	0. 8	15. 3	1. 6
Total	100. 0	100. 0	100. 0	100. 0	100. 0	100. 0

40+) men, as a group, inhale more smoke than women and start smoking when younger. This is illustrated in table 2 for men and women in age group 55 to 64 who were smoking 20 to 39 cigarettes a day when enrolled in the study.

TABLE 2.—Percentage distribution by degree of inhalation and age at start of smoking of men and women in age group 55–64 who currently smoked 20–39 cigarettes per day. Table confined to subjects with history of only cigarette smoking

Age at start of cigarette smoking	Degree of inhalation (%) None	Slight	Moderate	Deep	Total
	Men Currently Smoking 20–39 Cigarettes a Day (Age 55–64)				
30+	0. 8	1. 1	1. 9	0. 4	4. 2
25–29	0. 6	0. 9	2. 6	0. 7	4. 8
20–24	1. 8	3. 9	14. 0	4. 3	24. 0
15–19	2. 1	6. 4	31. 9	13. 2	53. 6
<15	0. 3	1. 4	6. 9	4. 8	13. 4
Total	5. 6	13. 7	57. 3	23. 4	100. 0
	Women Currently Smoking 20–39 Cigarettes a Day (Age 55–64)				
30+	8. 1	12. 8	20. 9	3. 6	45. 4
25–29	2. 6	4. 8	11. 9	2. 8	22. 1
20–24	2. 2	3. 9	10. 8	3. 1	20. 0
15–19	0. 9	2. 1	6. 1	2. 5	11. 6
<15	0. 1	0. 2	0. 2	0. 4	0. 9
Total	13. 9	23. 8	49. 9	12. 4	100. 0

With the three exposure variables taken jointly, current cigarette use may be divided into 80 classes [*i.e.*, amount (4) × degree of inhalation

(4) × age at start of smoking (5)]. Among persons of the same age, there are many men but very few women in certain classes and, conversely, many women but very few men in some other classes. Very few of the 80 classes contain reasonably large numbers of both men and women. This makes difficult a direct sex comparison with respect to the association between smoking and death rates.

In reading the tables shown later, one must keep in mind that a simple label such as "current cigarette smoker" has a different implication when applied to women than to men.

MATERIAL AND METHODS

The design and objectives of the study and information on many characteristics of the subjects have been described (*1–6*). A brief review of the salient facts follows:

Between October 1, 1959, and February 15, 1960, 68,116 volunteer workers of the American Cancer Society, Inc., enrolled 1,078,894 men and women in a prospective study. Care was taken to include all segments of the population except migrant workers and similar groups that could not have been traced and persons in long-term medical institutions, such as mental hospitals. Enrollment was by families (*i.e.*, households), with the specification that there be at least 1 person over age 45 in each family enrolled. All members of these families over 30 (except those too ill to do so) were requested to fill out detailed, confidential questionnaires containing questions on family history, past diseases, present physical complaints, occupation, occupational exposures, various habits, and many other factors. The questions concerning smoking habits are reproduced in Appendix figures 1 and 2. In some instances, when 1 member of a family was too ill or infirm to fill out a questionnaire, another member of the family did it for him. The subjects were traced annually and once every 2 years they were requested to fill out a brief follow-up questionnaire (*see* Appendix figures 3 and 4). Whenever a death was reported, we obtained a copy of the death certificate from the State or local health department. When cancer was mentioned on a death certificate, we wrote to the doctor requesting information on the basis of diagnosis and the histologic type of the neoplasm.

The study area included 1,121 counties of all sizes and types in 25 States.[2] For administrative purposes, the counties were divided into 1,370 units, with one unit for each of the small counties and several units within each of the very large counties. Of the 1,370 administrative units, 25 were unsuccessful in tracing the subjects in the last follow-up. The 11,268 subjects enrolled by these units are omitted from the present analysis. Altogether, 1,067,626 subjects were enrolled in the other 1,345

[2] Arizona, California, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, New York, North Carolina, Ohio, Oregon, Pennsylvania, South Carolina, Tennessee, Texas, and Virginia.

administrative units, but 22,539 of the questionnaires were unusable. This left a net total of 1,045,087 subjects effectively enrolled.

Of the 1,045,087 subjects, 1,040,744 (99.6%) were successfully traced through September 30, 1962, and 1,017,574 (97.4%) were successfully traced through September 30, 1963. At the end of the last follow-up, 971,362 were reported to be alive, 46,212 dead, and 27,513 "lost" as of September 30, 1963. Third questionnaire cards were filled out by (or for) 920,002 (94.7%) of the 971,362 subjects reported to be alive.

It should be noted that each successive follow-up yielded a few deaths which should have been reported in an earlier follow-up. Judged from this, it seems likely that deaths occurring during the last 12-month period (October 1, 1962, through September 30, 1963) have been somewhat understated, perhaps by as much as 4 or 5 percent. It seems unlikely that the present data include much underreporting of deaths for earlier periods.

We decided to confine the present analysis to 441,542 male and 568,797 female subjects between the ages of 35 and 84 at enrollment who were traced at least once. Subjects in age group 30 to 34 were omitted because of small numbers (and consequent unstable death rates) and subjects over 84 were omitted because the old age groups contained few men and women who smoked cigarettes. On review, it was found that 984 of the men and 6,126 of the women had filled out otherwise usable questionnaires but did not clearly state their smoking habits. For simplicity, we have omitted these subjects, which leaves a net total of 440,558 men and 562,671 women.

This paper covers 1,639,211 person-years of experience of the 440,558 men and 2,125,360 person-years of experience of the 562,671 women from enrollment through September 30, 1963. Altogether, 26,448 of the men and 16,773 of the women were reported to have died before October 1, 1963. So far, we have obtained copies of the death certificates for 25,895 (97.9%) of these men and 16,333 (97.4%) of these women. Appendix table 1 shows the numbers of subjects, deaths, and person-years of experience by sex for 5-year age groups. It will be noted that 54,399 of the subjects were in age group 35 to 39 and 105,595 in age group 40 to 44, while 212,514 were in age group 45 to 49. This distribution resulted from the specification that volunteers were to enroll only families in which at least 1 person was over 45.

As a first step in the analysis, the subjects were divided into 5-year groups by year of birth; these cohorts will be referred to by their ages as of the start of the study. In all instances, death rates were computed separately for each 5-year cohort by dividing the number of deaths by the number of person-years of experience. In other words, these are "cohort death rates" for specified groups during a 4-year period as distinguished from "attained age death rates" for designated age groups consisting of different sets of people in each of 4 years. The 5-year cohort death rates are shown in Appendix tables. To reduce the size of the tables (and for greater statistical stability) death rates are shown in text tables for 10-year or broader age groups. The latter rates are based on the 5-year

cohort rates and standardized on the age distribution of person-years of all subjects (men and women), as shown in the next-to-last column of Appendix table 1.

In some 5-year age-sex groups, certain smoking classes contained so few subjects that the total death rate (*i.e.*, the death rate from all causes combined) would be very unstable. Total death rates are shown in the Appendix tables only if 10 or more deaths could be expected under the null hypothesis, that is, when the product of person-years times the total death rate of all subjects in the same sex and 5-year age group (disregarding smoking habits) was at least 10; otherwise, the symbol (*) is inserted in place of the death rate. Age-standardized total death rates are shown in text tables only when death rates are shown for every one of the component 5-year age-sex groups in the corresponding Appendix table.

Age-standardized death rates shown in text tables for individual diseases were also based on death rates computed for each 5-year age group. However, for individual diseases (other than coronary heart disease), we did not impose the restriction of a minimum of 10 expected deaths within each 5-year age-sex group of a particular smoking category.

As used in this paper, the term "mortality ratio" means the age-standardized death rate of a particular category of smokers divided by the age-standardized death rate of subjects of the same age and sex who never smoked regularly. By definition, the mortality ratio of subjects who never smoked regularly is 1.00.

A few subjects did not answer all the questions pertaining to smoking habits. For example, some said how many cigarettes they smoked per day but did not state how deeply they inhaled nor tell the age at which they began to smoke. Such individuals have been omitted from certain tables. For example, subjects not saying how deeply they inhaled or when they began to smoke are omitted from tables 6 and 7, respectively.

TOTAL DEATH RATES

Disregarding smoking habits, the death rates of men were far higher than those of women (table 3). The sex differential in death rates is somewhat diminished but is still large among subjects who never smoked regularly.

TABLE 3.—Age-standardized death rates of all subjects and subjects who never smoked regularly, by age at start of study

Sex	Age 35–44	45–54	55–64	65–74	75–84
	All Subjects; All Causes of Death				
Men	334	728	1, 796	3, 909	8, 633
Women	174	337	732	1, 957	5, 874
	Never Smoked Regularly; All Causes of Death				
Men	211	402	1, 187	3, 118	7, 897
Women	164	302	690	1, 892	5, 836

Table 4 shows death rates and mortality ratios by type of smoking based on lifetime history, disregarding whether the subjects were current smokers when they enrolled in the study.

The findings for males are very similar to those reported previously (*7–12*). Men who never smoked regularly and men with a history of only pipe smoking had the lowest death rates. Men with a history of only cigar smoking had slightly higher death rates. Men with a history of cigarette and other smoking had far higher death rates; and those with a history of only cigarette smoking had the highest death rates. The mortality ratios for men with a history of only cigarette smoking varied with age, being highest in age group 45 to 54 and lowest in group 75 to 84. In age group 45 to 54, the death rate of men with a history of only cigarette smoking was more than double that of men who never smoked regularly.

In table 4, the female subjects are divided into two classes: never smoked regularly and history of regular cigarette smoking. In all 5 age groups, women with a history of cigarette smoking had the higher death rates. However, the mortality ratios for women with a history of cigarette smoking were much lower than the corresponding mortality ratios for men. For example, in age group 45 to 54, the mortality ratio of subjects

TABLE 4.—Age-standardized death rates and mortality ratios by type of smoking (lifetime history) and age at start of study

Type of smoking (lifetime history)	Age 35–44	45–54	55–64	65–74	75–84
	Death Rates per 100,000 Person-Years				
Men					
Never smoked regularly	211	402	1, 187	3, 118	7, 897
Pipe only	*	386	1, 407	3, 291	7, 527
Pipe and cigar	*	456	1, 204	3, 326	8, 830
Cigar only	*	471	1, 481	3, 269	8, 398
Cigarette and other	353	754	1, 858	4, 225	9, 030
Cigarette only	384	886	2, 207	4, 918	10, 635
Women					
Never smoked regularly	164	302	690	1, 892	5, 836
Cigarette	184	395	878	2, 471	6, 634
	Mortality Ratios				
Men					
Never smoked regularly	1. 00	1. 00	1. 00	1. 00	1. 00
Pipe only	*	0. 96	1. 19	1. 06	0. 95
Pipe and cigar	*	1. 13	1. 01	1. 07	1. 12
Cigar only	*	1. 17	1. 25	1. 05	1. 06
Cigarette and other	1. 67	1. 88	1. 57	1. 36	1. 14
Cigarette only	1. 82	2. 20	1. 86	1. 58	1. 35
Women					
Never smoked regularly	1. 00	1. 00	1. 00	1. 00	1. 00
Cigarette	1. 12	1. 31	1. 27	1. 31	1. 14

*Death rate omitted when number of person-years times total death rate for age-sex group yields expected number of less than 10 deaths.

with a history of only cigarette smoking was 1.31 for women, compared with 2.20 for men. In age group 65 to 74, the sex difference was not so striking, the mortality ratio of subjects with a history of only cigarette smoking being 1.31 for women and 1.58 for men.

"Current smokers" are defined as subjects who said they were smoking regularly when they enrolled in the study. Tables 5 through 9 are confined to current cigarette smokers with a history of only cigarette smoking. (A very small proportion of the women may have smoked pipes or cigars at some time during their lives.) Death rates and mortality ratios are shown in relation to number of cigarettes currently smoked per day at time of enrollment, degree of inhalation, and the ages at which the subjects first began to smoke cigarettes.

Among both men and women, death rates increased with number of cigarettes smoked per day (table 5). However, within each of the 4 amount-of-smoking categories, the mortality ratios were far higher for

TABLE 5.—Age-standardized death rates and mortality ratios for subjects with history of only cigarette smoking, who were currently smoking cigarettes at enrollment, by current number of cigarettes smoked per day and age at start of study. Death rates for subjects who never smoked regularly are shown for comparison

Current No. of cigarettes per day	Age				
	35–44	45–54	55–64	65–74	75–84
DEATH RATES PER 100,000 PERSON-YEARS					
Men With History of Only Cigarette Smoking					
1–9	*	741	1, 815	4, 683	10, 741
10–19	286	910	2, 280	5, 145	12, 268
20–39	404	970	2, 437	5, 325	9, 982
40+	546	1, 109	2, 680	5, 635	*
Women With History of Cigarette Smoking					
1–9	147	288	682	2, 055	6, 217
10–19	159	368	904	2, 238	7, 064
20–39	221	464	1, 010	2, 862	*
40+	*	592	*	*	*
Men and Women Who Never Smoked Regularly					
None (men)	211	402	1, 187	3, 118	7, 897
None (women)	164	302	690	1, 892	5, 836
MORTALITY RATIOS					
Men With History of Only Cigarette Smoking					
1–9	*	1. 84	1. 53	1. 50	1. 36
10–19	1. 36	2. 26	1. 92	1. 65	1. 55
20–39	1. 91	2. 41	2. 05	1. 71	1. 26
40+	2. 59	2. 76	2. 26	1. 81	*
Women With History of Cigarette Smoking					
1–9	0. 90	0. 95	0. 99	1. 09	1. 07
10–19	. 97	1. 22	1. 31	1. 18	1. 21
20–39	1. 35	1. 54	1. 46	1. 51	*
40+	*	1. 96	*	*	*

*See footnote, table 4.

men than for women. Men smoking as few as 1 to 9 cigarettes a day at enrollment had death rates considerably higher than those for men who never smoked regularly. In contrast, women who smoked 1 to 9 cigarettes a day had death rates about the same as women who never smoked regularly (slightly lower in 3 age groups and slightly higher in 2).

Among subjects in age group 45 to 54, the mortality ratio was 2.41 for men and 1.54 for women who smoked 20 to 39 cigarettes per day, and 2.76 for men and 1.96 for women who smoked 40 or more per day. In other age groups there were so few women who smoked 40 or more cigarettes per day that we did not compute their death rates.

As shown in table 6, the death rates of current cigarette smokers, both male and female, tended to increase with the degree to which the subjects said they inhaled the smoke. Again, the mortality ratios were far higher for men than for women.

TABLE 6.—Age-standardized death rates and mortality ratios for subjects with a history of only cigarette smoking, who were currently smoking cigarettes at enrollment, by degree of inhalation and age at start of study. Death rates for subjects who never smoked regularly are shown for comparison

Degree of inhalation	Age 35–44	45–54	55–64	65–74	75–84
	DEATH RATES PER 100,000 PERSON-YEARS				
	Men With History of Only Cigarette Smoking				
None	*	824	1,868	3,994	9,329
Slight	*	859	2,376	5,029	11,367
Moderate	407	974	2,331	5,300	10,341
Deep	394	1,021	2,689	6,411	16,410
	Women With History of Cigarette Smoking				
None	*	305	763	2,117	5,601
Slight	200	364	884	2,384	7,054
Moderate	173	394	911	2,676	*
Deep	230	537	1,129	*	*
	Men and Women Who Never Smoked Regularly				
None (men)	211	402	1,187	3,118	7,897
None (women)	164	302	690	1,892	5,836
	MORTALITY RATIOS				
	Men With History of Only Cigarette Smoking				
None	*	2.05	1.57	1.28	1.18
Slight	*	2.14	2.00	1.61	1.44
Moderate	1.93	2.42	1.96	1.70	1.31
Deep	1.87	2.54	2.27	2.06	2.08
	Women With History of Cigarette Smoking				
None	*	1.01	1.11	1.12	0.96
Slight	1.22	1.21	1.28	1.26	1.21
Moderate	1.05	1.30	1.32	1.41	*
Deep	1.40	1.78	1.64	*	*

*See footnote, table 4.

Table 7 shows death rates of current cigarette smokers in relation to the ages at which they first began to smoke. In both sexes, death rates were higher among subjects who started the habit when young. The highest death rates for men were among those who began smoking cigarettes before age 15. So few women began to smoke at such an early age that these particular death rates were not computed.

TABLE 7.—Age-standardized death rates and mortality ratios for subjects with a history of only cigarette smoking, who were currently smoking cigarettes at enrollment, by age began cigarette smoking and age at start of study. Death rates for subjects who never smoked regularly are shown for comparison

Age began cigarette smoking	Age 35–44	45–54	55–64	65–74	75–84
	DEATH RATES PER 100,000 PERSON-YEARS				
	Men With History of Only Cigarette Smoking				
30 or older	*	562	1, 576	3, 846	8, 699
25–29	*	726	2, 082	3, 902	*
20–24	283	857	2, 058	4, 728	10, 054
15–19	438	999	2, 509	5, 728	12, 482
<15	*	1, 210	2, 682	6, 221	12, 589
	Women With History of Cigarette Smoking				
30 or older	*	332	834	2, 185	5, 527
25–29	*	391	841	2, 408	*
20–24	229	394	984	*	*
15–19	187	416	987	*	*
<15	*	*	*	*	*
	Men and Women Who Never Smoked Regularly				
None (men)	211	402	1, 187	3, 118	7, 897
None (women)	164	302	690	1, 892	5, 836
	MORTALITY RATIOS				
	Men With History of Only Cigarette Smoking				
30 or older	*	1. 40	1. 33	1. 23	1. 10
25–29	*	1. 81	1. 75	1. 25	*
20–24	1. 34	2. 13	1. 73	1. 52	1. 27
15–19	2. 08	2. 49	2. 11	1. 84	1. 58
<15	*	3. 01	2. 26	2. 00	1. 59
	Women With History of Cigarette Smoking				
30 or older	*	1. 10	1. 21	1. 15	0. 95
25–29	*	1. 29	1. 22	1. 27	*
20–24	1. 40	1. 30	1. 43	*	*
15–19	1. 14	1. 38	1. 43	*	*
<15	*	*	*	*	*

*See footnote, table 4.

Attention should be called to the fact that within specific age-sex groups the three exposure variables are correlated with each other. For example, among men in age group 45 to 49, those who began smoking

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before age 15 tended to smoke many cigarettes a day and inhale moderately or deeply while those who began smoking after 30 tended to smoke few cigarettes a day and inhale none or slightly (*4*). This point should be kept in mind in considering the findings described above.

In tables 5, 6, and 7, three different exposure variables have been considered one at a time: number of cigarettes smoked per day, degree of inhalation, and age began cigarette smoking. As noted, men differed from women with respect to all three variables taken singly or jointly (tables 1 and 2). Similarly, middle-aged men tended to differ from old men and middle-aged women tended to differ from old ones. Therefore, it would be desirable to compare death rates and mortality ratios among groups of people (men and women, young and old) who are alike with respect to all three exposure variables. This feat is difficult to accomplish for the very reason that cigarette smoking habits differ so greatly in the several age-sex groups. Many combinations of the variables taken two at a time are quite common in some age-sex groups, but rare or almost nonexistent in others, and the disparity between groups is even more pronounced for combinations taken three at a time. This placed rather severe restrictions on multivariate analyses.

Table 8 shows death rates and mortality ratios of men and women by both current number of cigarettes smoked per day and age began cigarette smoking. Because of the difficulties mentioned above, age began cigarette smoking was divided into just three categories: began cigarette smoking after 25, between 15 and 24, and under 15. So few women began smoking before age 15 that they could not be subdivided by current rate of use.

Among subjects who began smoking at about the same age, death rates tended to increase with number of cigarettes currently smoked per day. Among subjects who currently smoked the same number of cigarettes per day, death rates tended to be higher in those beginning at younger ages. This was generally true for both men and women in all age groups, although the pattern is not completely consistent. Death rates were especially high among men who began smoking cigarettes before 15, regardless of the number they currently smoked per day at enrollment. There is reason to believe that some men in this group previously smoked 40 or more cigarettes per day but had reduced their consumption because of ill health (*13*).

Table 9 shows death rates and mortality ratios of men and women by both current number of cigarettes smoked per day and degree of inhalation. Degree of inhalation is divided for this presentation into two categories: none-slight and moderate-deep. Among subjects who were alike in respect to either one of these two variables, death rates tended to rise with the other variable. Again, the contrasts depicted by mortality ratios were greater among males than females.

Unfortunately, the disparity in smoking habits between men and women is so great that the available observations did not permit a comparison of male and female death rates among cigarette smokers alike in

TABLE 8.—Age-standardized death rates and mortality ratios for subjects with history of only cigarette smoking who were currently smoking cigarettes at enrollment, by number of cigarettes smoked per day, age began smoking, and age at start of study

Current number of cigarettes per day	Men			Women		
	Age began smoking			Age began smoking		
	25+	15–24	<15	25+	15–24	<15
	Death Rates—Subjects Aged 45–54 at Start of Study					
1–9	*	809	*	288	267	*
10–19	705	885	1, 383	353	371	*
20–39	700	956	1, 189	403	485	*
40+	*	1, 102	1, 294	*	558	*
	Death Rates—Subjects Aged 55–64 at Start of Study					
1–9	1, 585	1, 717	*	667	871	*
10–19	1, 989	2, 245	2, 554	881	931	*
20–39	1, 755	2, 436	2, 595	961	1, 150	*
40+	2, 104	2, 647	3, 062	*	*	*
	Death Rates—Subjects Aged 65–74 at Start of Study					
1–9	3, 108	5, 262	6, 687	1, 977	*	*
10–19	4, 213	5, 151	6, 845	2, 040	*	*
20–39	4, 476	5, 390	6, 177	2, 678	*	*
40+	*	6, 672	*	*	*	*
	Mortality Ratios—Subjects Aged 45–54 at Start of Study					
1–9	*	2. 01	*	0. 95	0. 88	*
10–19	1. 75	2. 20	3. 44	1. 17	1. 23	*
20–39	1. 74	2. 38	2. 96	1. 33	1. 61	*
40+	*	2. 74	3. 22	*	1. 85	*
	Mortality Ratios—Subjects Aged 55–64 at Start of Study					
1–9	1. 34	1. 45	*	0. 97	1. 26	*
10–19	1. 68	1. 89	2. 15	1. 28	1. 35	*
20–39	1. 48	2. 05	2. 19	1. 39	1. 67	*
40+	1. 77	2. 23	2. 58	*	*	*
	Mortality Ratios—Subjects Aged 65–74 at Start of Study					
1–9	1. 00	1. 69	2. 14	1. 04	*	*
10–19	1. 35	1. 65	2. 20	1. 08	*	*
20–39	1. 44	1. 73	1. 98	1. 42	*	*
40+	*	2. 14	*	*	*	*

*See footnote, table 4.

respect to all three variables. Perhaps mortality ratios would be the same for male and female cigarette smokers with identical smoking histories. Even in this event, the absolute difference in death rates between cigarette smokers and nonsmokers would be greater in men than in women. For example, in age group 45 to 54, the death rate per 100,000 person-years among nonsmokers was 402 for men and 302 for women. Now, let us suppose that light cigarette smokers in this age group had a mortality ratio of 1.50 regardless of sex. In that event, the increase in death rates associated with "light cigarette smoking" would be 201 per 100,000 person-years for men but only 151 per 100,000 person-years for women.

TABLE 9.—Age-standardized death rates and mortality ratios for subjects with history of only cigarette smoking who were currently smoking cigarettes at enrollment, by number of cigarettes smoked per day, degree of inhalation, and age at start of study

Current number of cigarettes per day	Men		Women	
	Degree of inhalation		Degree of inhalation	
	None-slight	Moderate-deep	None-slight	Moderate-deep
Death Rates—Subjects Aged 45–54 at Start of Study				
1–9	683	785	256	315
10–19	799	945	385	352
20–39	941	973	426	477
40+	937	1, 124	*	660
Death Rates—Subjects Aged 55–64 at Start of Study				
1–9	1, 712	1, 900	681	797
10–19	2, 180	2, 258	949	843
20–39	2, 370	2, 406	947	1, 079
40+	2, 185	2, 786	*	*
Death Rates—Subjects Aged 65–74 at Start of Study				
1–9	4, 516	5, 032	1, 998	*
10–19	4, 437	5, 678	2, 134	2, 352
20–39	4, 811	5, 635	2, 697	3, 101
40+	*	5, 358	*	*
Mortality Ratios—Subjects Aged 45–54 at Start of Study				
1–9	1. 70	1. 95	0. 85	1. 04
10–19	1. 99	2. 35	1. 27	1. 17
20–39	2. 34	2. 42	1. 41	1. 58
40+	2. 33	2. 80	*	2. 19
Mortality Ratios—Subjects Aged 55–64 at Start of Study				
1–9	1. 44	1. 60	0. 99	1. 16
10–19	1. 84	1. 90	1. 38	1. 22
20–39	2. 00	2. 03	1. 37	1. 56
40+	1. 84	2. 35	*	*
Mortality Ratios—Subjects Aged 65–74 at Start of Study				
1–9	1. 45	1. 61	1. 06	*
10–19	1. 42	1. 82	1. 13	1. 24
20–39	1. 54	1. 81	1. 43	1. 64
40+	*	1. 72	*	*

*See footnote, table 4.

"CIGARETTE AND OTHER" SMOKERS

A substantial number of men had a history of smoking cigarettes and pipes and/or cigars as well. We refer to these as "cigarette and other" smokers. They were a heterogeneous group in respect to their current practices at enrollment in the study: some currently smoked cigarettes and pipes or cigars; some, only cigarettes; some, only pipes or cigars; and some had stopped smoking altogether. We do not have a year-by-year record of their habits, but it is likely that many smoked only one type

during certain periods of their lives and then switched to another type (*e.g.*, from pipes to cigarettes). As a group, they smoked fewer cigarettes per day, inhaled less deeply, and started smoking cigarettes at an older age than did men with a history of only cigarette smoking (*3*, *4*).

Men with a lifetime history of "cigarette and other" smoking had lower death rates than men with a lifetime history of only cigarette smoking (table 4). Table 10 shows the death rates of those currently smoking cigarettes when they enrolled in the study; some were currently smoking pipes or cigars as well as cigarettes. They are classified by current number of cigarettes smoked per day, degree of inhalation, and age at start of cigarette smoking. The findings were generally similar to those previously

TABLE 10. Age-standardized death rates for men with a history of cigarette and other smoking, by current number of cigarettes smoked per day, degree of inhalation of cigarette smoke, by age began cigarette smoking, and age at start of study

Number of cigarettes per day, degree of inhalation, and age began	Age				
	35–44	45–54	55–64	65–74	75–84
	Death Rates per 100,000 Person-Years				
Current number of cigarettes a day:					
1–9	*	568	1, 826	4, 092	9, 860
10–19	*	795	1, 756	4, 747	8, 083
20–39	427	851	2, 036	4, 719	9, 595
40+	*	1, 097	2, 902	*	*
Degree of inhalation:					
None	*	566	1, 703	4, 126	8, 063
Slight	*	672	2, 035	4, 082	9, 386
Moderate	385	829	1, 991	4, 768	8, 666
Deep	*	1, 019	2, 229	5, 223	*
Age began cigarette smoking:					
30 or older	*	554	2, 142	4, 107	8, 018
25–29	*	508	1, 700	3, 942	*
20–24	*	740	1, 784	4, 343	9, 810
15–19	388	826	2, 051	4, 810	9, 811
<15	*	1, 106	2, 347	4, 852	*
Never smoked regularly	211	402	1, 187	3, 118	7, 897
	Mortality Ratios				
Current number of cigarettes a day:					
1–9	*	1. 41	1. 54	1. 31	1. 25
10–19	*	1. 98	1. 48	1. 52	1. 02
20–39	2. 02	2. 12	1. 72	1. 51	1. 22
40+	*	2. 73	2. 44	*	*
Degree of inhalation:					
None	*	1. 41	1. 43	1. 32	1. 02
Slight	*	1. 67	1. 71	1. 31	1. 19
Moderate	1. 82	2. 06	1. 68	1. 53	1. 10
Deep	*	2. 53	1. 88	1. 68	*
Age began cigarette smoking:					
30 or older	*	1. 38	1. 80	1. 32	1. 02
25–29	*	1. 26	1. 43	1. 26	*
20–24	*	1. 84	1. 50	1. 39	1. 24
15–19	1. 84	2. 05	1. 73	1. 54	1. 24
<15	*	2. 75	1. 98	1. 56	*

*See footnote, table 4.

described for current cigarette smokers with a history of only cigarette smoking. However, among men who currently smoked the same number of cigarettes per day, death rates tended to be somewhat lower for the "cigarette and other" group than for the "cigarette only" group. This is probably because, in general, they inhaled less deeply and had started cigarette smoking later in life. It also seems likely that the lifetime consumption of cigarettes was less, on the average, for the "cigarette and other" group than for the "cigarette only" group.

EX-CIGARETTE SMOKERS

Table 11, which is confined to men with a history of only cigarette smoking, compares death rates of ex-cigarette smokers with death rates of current cigarette smokers and men who never smoked regularly. The smokers are divided into two groups: those who smoked (or formerly smoked) less than 20 cigarettes per day and those who smoked (or formerly smoked) 20 or more per day. The ex-smokers are subdivided by the number of years between the time they last smoked and time of entry in the study. Due to small numbers, the death rates by 10-year age groups are rather unstable statistically for some groups of ex-smokers. Therefore, we have also shown age-standardized death rates for a broader age range (50–74).

The death rates of ex-cigarette smokers who formerly smoked less than 20 a day declined with length of interval since discontinuance. Even those who had stopped less than 1 year before entry in the study had death rates lower than the current cigarette smokers. Those who had stopped smoking for 10 years or longer before enrollment had about the same death rates as men who never smoked regularly. The death rates of ex-cigarette smokers who formerly smoked 20 or more per day also declined with time since discontinuance. Those who had stopped smoking for 5 years or longer had death rates below those of current cigarette smokers. Men who had stopped smoking for 10 years or longer had death rates much lower than the death rates of current smokers, but still higher than the rates for nonsmokers.

Attention is called to the high death rates of ex-cigarette smokers who formerly smoked 20 or more cigarettes per day and who had stopped smoking less than 1 year before enrollment. As discussed in another paper, many of these men had given up smoking because of some serious illness, and many of them returned to smoking after entry in the study (*13*). This adequately explains why the death rates of this particular group of ex-cigarette smokers were higher than those of men who were currently smoking cigarettes when they enrolled in the study.

There were relatively few female ex-cigarette smokers who had smoked a substantial number of cigarettes during their lifetimes. For this reason, we have not made a parallel analysis for women.

TABLE 11.—Age-standardized death rates and mortality ratios for men with a history of cigarette smoking only who had given up smoking at start of study, by former amount of cigarettes smoked per day, and by years since last smoked. Death rates of current cigarette smokers and men who never smoked regularly are shown for comparison

Type of smoking	Age 45–54	55–64	65–74	75–84	Subtotal 50–74
Ex-cigarette smokers	HAD SMOKED 1–19 CIGARETTES A DAY				
Years since last cigarette smoking:	Death Rates per 100,000 Person-Years				
<1 year	*	2, 017	4, 607	*	2, 212
1–4 years	437	1, 854	4, 796	*	1, 985
5–9 years	751	1, 669	3, 682	*	1, 840
10+ years	389	1, 020	3, 681	8, 753	1, 397
Current cigarette smokers	858	2, 127	4, 974	11, 496	2, 359
Never smoked regularly	402	1, 187	3, 118	7, 897	1, 374
	Mortality Ratios				
<1 year	*	1. 70	1. 48	*	1. 61
1–4 years	1. 09	1. 56	1. 54	*	1. 44
5–9 years	1. 87	1. 41	1. 18	*	1. 34
10+ years	0. 97	0. 86	1. 18	1. 11	1. 02
Current cigarette smokers	2. 13	1. 79	1. 60	1. 46	1. 72
Ex-cigarette smokers	HAD SMOKED 20 OR MORE CIGARETTES A DAY				
Years since last cigarette smoking:	Death Rates per 100,000 Person-Years				
<1 year	1, 056	2, 962	6, 339	*	2, 995
1–4	887	2, 613	5, 488	*	2, 715
5–9 years	616	1, 880	4, 260	*	2, 047
10+ years	436	1, 563	4, 399	10, 094	1, 814
Current cigarette smokers	996	2, 478	5, 357	10, 011	2, 659
	Mortality Ratios				
<1 year	2. 63	2. 50	2. 03	*	2. 18
1–4 years	2. 21	2. 20	1. 76	*	1. 98
5–9 years	1. 53	1. 58	1. 37	*	1. 49
10+ years	1. 08	1. 32	1. 41	1. 28	1. 32
Current cigarette smokers	2. 48	2. 09	1. 72	1. 27	1. 94

*See footnote, table 4.

PIPE AND CIGAR SMOKING

There were relatively few men with a lifetime history of only pipe or only cigar smoking; consequently, their age-specific death rates are less stable statistically than the rates reported for male cigarette smokers.

As noted in table 4, the death rates of men with a history of only pipe smoking differed little from the rates of men who never smoked regularly.

Further details are given in table 12. It is of interest that the death rates of ex-pipe smokers were higher than for current pipe smokers. This is almost certainly due to the influence of health on smoking habits as discussed elsewhere (*13*). That is, while pipe smoking seems to do little or no harm to the average pipe smoker, ill health may lead a pipe smoker to give up the habit.

Most pipe smokers said they did not inhale; and a majority of the remainder said they inhaled only slightly. The current pipe smokers who inhaled at least slightly had somewhat higher death rates, on the average, than men who never smoked regularly. This difference was not large and not consistently found in all age groups.

TABLE 12.—Age-standardized death rates and mortality ratios for men with history of only pipe smoking, by number of pipefuls smoked per day and degree of inhalation at start of study. Death rates for men who never smoked regularly are shown for comparison

History of pipe only	Age 45–54	Age 55–64	Age 65–74	Age 75–84	Subtotal 45–64	Subtotal 65–84
	Death Rates per 100,000 Person-Years					
Pipe smokers (total)	386	1, 407	3, 291	7, 527	786	4, 140
Ex-pipe smokers	510	1, 598	4, 030	7, 841	935	4, 792
Current pipe smokers (total)	346	1, 337	2, 973	7, 382	734	3, 856
1–9 a day	404	1, 327	2, 825	7, 900	765	3, 841
10+ a day	295	1, 199	3, 145	5, 791	649	3, 675
No inhalation	345	1, 232	2, 613	7, 177	692	3, 527
Some inhalation	337	1, 667	3, 876	7, 096	857	4, 522
Never smoked regularly	402	1, 187	3, 118	7, 897	709	4, 075
	Mortality Ratios					
Pipe smokers (total)	0. 96	1. 19	1. 06	0. 95	1. 11	1. 02
Ex-pipe smokers	1. 27	1. 35	1. 29	0. 99	1. 32	1. 18
Current pipe smokers (total)	0. 86	1. 13	0. 95	0. 93	1. 04	0. 95
1–9 a day	1. 00	1. 12	0. 91	1. 00	1. 08	0. 94
10+ a day	0. 73	1. 01	1. 01	0. 73	0. 92	0. 90
No inhalation	0. 86	1. 04	0. 84	0. 91	0. 98	0. 87
Some inhalation	0. 84	1. 40	1. 24	0. 90	1. 21	1. 11

Men with a history of only cigar smoking had death rates somewhat higher than men who never smoked regularly (table 4). As for pipe smokers, the death rates of ex-cigar smokers were higher than the rates of current cigar smokers (table 13). Cigar smokers also tend to inhale far less deeply than cigarette smokers. The death rates of current cigar smokers who said they inhaled at least slightly were appreciably higher than for men who never smoked regularly.

TABLE 13.—Age-standardized death rates and mortality ratios for men with history of only cigar smoking, by number of cigars smoked per day and degree of inhalation at start of study. Death rates for men who never smoked regularly are shown for comparison

History of cigar only	Age 45–54	55–64	65–74	75–84	Sub-total 45–64	Sub-total 65–84
	Death Rates per 100,000 Person-Years					
Cigar smokers (total)	471	1, 481	3, 269	8, 398	866	4, 296
Ex-cigar smokers	*	1, 893	3, 672	9, 374	1, 199	4, 813
Current cigar smokers (total)	408	1, 336	3, 056	7, 676	771	3, 981
1–4 a day	364	1, 303	3, 142	7, 668	732	4, 049
5+ a day	517	1, 335	2, 845	7, 086	837	3, 694
No inhalation	336	1, 317	2, 758	7, 473	720	3, 702
Some inhalation	603	1, 389	4, 698	9, 052	911	5, 571
Never smoked regularly	402	1, 187	3, 118	7, 897	709	4, 075
	Mortality Ratios					
Cigar smokers (total)	1. 17	1. 25	1. 05	1. 06	1. 22	1. 05
Ex-cigar smokers	*	1. 59	1. 18	1. 19	1. 41	1. 18
Current cigar smokers (total)	1. 01	1. 13	0. 98	0. 97	1. 09	0. 98
1–4 a day	0. 91	1. 10	1. 01	0. 97	1. 03	0. 99
5+ a day	1. 29	1. 12	0. 91	0. 90	1. 18	0. 91
No inhalation	0. 84	1. 11	0. 88	0. 95	1. 02	0. 91
Some inhalation	1. 50	1. 17	1. 51	1. 15	1. 28	1. 37

* *See* footnote, table 4.

CAUSES OF DEATH

At the time this paper was written, we had obtained copies of death certificates for 42,228 (97.7%) of the 43,221 reported deaths. Each was classified by "underlying cause" of death according to the rules of the Seventh Revision of the International Statistical Classification of Diseases, Injuries, and Causes of Death. In addition, two "contributing causes" were coded if mentioned on the death certificate. When cancer was reported on a death certificate, we requested the certifying doctor to inform us of the basis of diagnosis and the histologic type of the neoplasm. So far, we have received replies on 89 percent of the deaths reportedly due to cancer. In some instances, the doctor amended his certification, and assignment of causes of death took note of such information.

It should be noted that coding of bronchitis and emphysema departed from strict adherence to the International List. When bronchitis and emphysema appeared on a death certificate as the joint cause of death, we assigned the death to emphysema rather than to bronchitis. This

decision was based on findings in autopsy studies (*14*, *15*). Cancer of the trachea and cancer of the pleura were excluded from the lung cancer category.

Appendix table 13 shows the deaths classified by "underlying cause." Coronary heart disease (CHD) was by far the leading cause of death, accounting for 11,556 (44.6%) of the male deaths and 4,654 (28.5%) of the female deaths. Cerebral vascular lesions were second, accounting for 2,227 (8.6%) of the male deaths and 2,010 (12.3%) of the female deaths. Lung cancer in men and breast cancer in women were third. Lung cancer accounted for 1,159 (4.5%) of the male deaths but only 210 (1.3%) of the female deaths. Breast cancer accounted for 1,318 (8.1%) of female deaths.

Coronary heart disease accounted for so many deaths that we were able to carry out an analysis in almost the same detail as for total deaths. Except as noted for table 16, death rates were not computed for a particular cell in a table unless at least 10 CHD deaths could be expected under the null hypothesis for each of the 5-year age-sex groups included in an age-standardized death rate.

To present a fairly comprehensive analysis of death rates from cerebral vascular lesions, we had to relax our standard of statistical stability. Death rates are not presented in table 18 unless at least 4 CVL deaths were expected under the null hypothesis for each of the 5-year age-sex groups included in an age-standardized death rate. Otherwise, the symbol (‡) is inserted. If only 4 to 9 deaths were expected under the null hypothesis in a component 5-year age-sex group, then the death rate in table 18 is so indicated by the symbol (†).

A less detailed analysis was carried out for other causes of death because of smaller numbers. Age-standardized death rates were computed, regardless of the number of deaths expected under the null hypothesis. Some of the death rates shown for relatively rare diseases, therefore, are unstable and should be read with caution.

CORONARY HEART DISEASE

Death rates from coronary heart disease were far higher for men than for women, the sex difference being particularly pronounced among subjects under 65. This finding is in accord with the U.S. data published by the National Office of Vital Statistics.

Table 14 shows death rates from coronary heart disease (underlying cause) in relation to type of smoking (lifetime history). Men who never smoked regularly and pipe smokers had the lowest CHD death rates while cigar smokers tended to have slightly higher rates. Cigarette smokers had by far the highest CHD death rates. Among men with a history of only cigarette smoking the CHD mortality ratio was highest (2.81) in age group 45 to 54 and declined with age to 1.24 in age group 75 to 84. Among women in age group 45 to 54, the CHD death rate among cigarette

smokers was twice that for nonsmokers (mortality ratio 2.00). As with males, the CHD mortality ratio for female cigarette smokers declined with age. In age group 65 to 74, the mortality ratio for subjects with a history of only cigarette smoking was about the same for men and women.

TABLE 14.—Coronary heart disease. Age-standardized death rates, by type of smoking (lifetime history) and age at start of study

Type of smoking (lifetime history)	Age 35–44	45–54	55–64	65–74	75–84
	CHD Death Rates per 100,000 Person-Years				
Men					
Never smoked regularly	*	150	542	1, 400	3, 132
Pipe only	*	141	647	1, 396	3, 005
Pipe and cigar	*	200	560	1, 362	3, 594
Cigar only	*	173	734	1, 300	3, 439
Cigarette and other	*	363	854	1, 839	3, 627
Cigarette only	148	422	996	2, 025	3, 871
Total	122	336	822	1, 662	3, 404
Women					
Never smoked regularly	*	33	163	653	1, 973
Cigarette	*	66	275	941	2, 349
Total	15	45	188	686	1, 987
	CHD Mortality Ratios				
Men					
Never smoked regularly	*	1. 00	1. 00	1. 00	1. 00
Pipe only	*	0. 94	1. 19	1. 00	0. 96
Pipe and cigar	*	1. 33	1. 03	0. 97	1. 15
Cigar only	*	1. 15	1. 35	0. 93	1. 10
Cigarette and other	*	2. 42	1. 58	1. 31	1. 16
Cigarette only	*	2. 81	1. 84	1. 45	1. 24
Women					
Never smoked regularly	*	1. 00	1. 00	1. 00	1. 00
Cigarette	*	2. 00	1. 69	1. 44	1. 19

*See footnote, table 4.

Table 15 (a and b) is restricted to current cigarette smokers with a history of only cigarette smoking. CHD death rates are shown in relation to current number of cigarettes smoked per day, degree of inhalation, and age began cigarette smoking. The CHD death rates of men tended to increase directly with all three exposure variables. The CHD death rates of women increased with amount of cigarette smoking and degree of inhalation, but not with age began smoking.

Table 16, which deals with men in age group 50 to 69 with a history of only cigarette smoking, shows CHD death rates of ex-cigarette smokers by amount formerly smoked in relation to length of time discontinued as of entry into the study. The death rates of current cigarette smokers and men who never smoked regularly are shown for comparison. Recent

TABLE 15a.—Coronary heart disease. Age-standardized death rates and mortality ratios of subjects with history of only cigarette smoking, by current number of cigarettes smoked per day, degree of inhalation, age began smoking, and age at start of study

Number of cigarettes per day, degree of inhalation, and age began smoking	Age				
	35–44	45–54	55–64	65–74	75–84
	CHD Death Rates per 100,000 Person-Years (Men)				
Current number of cigarettes per day					
1–9	*	352	837	1, 758	3, 670
10–19	*	463	1, 039	2, 254	4, 347
20–39	167	467	1, 104	2, 188	3, 473
40+	*	503	1, 152	*	*
Degree of inhalation					
None-slight	*	400	994	1, 835	4, 036
Moderate-deep	165	476	1, 090	2, 281	3, 768
Age began cigarette smoking					
25 or older	*	356	922	1, 632	3, 018
15–24	167	466	1, 077	2, 268	4, 259
<15	*	520	1, 130	2, 152	*
Never smoked regularly	*	150	542	1, 400	3, 132
	Mortality Ratios (Men)				
Current number of cigarettes per day					
1–9	*	2. 35	1. 54	1. 26	1. 17
10–19	*	3. 09	1. 92	1. 61	1. 39
20–39	*	3. 11	2. 04	1. 56	1. 11
40+	*	3. 35	2. 13	*	*
Degree of inhalation					
None-slight	*	2. 67	1. 83	1. 31	1. 29
Moderate-deep	*	3. 17	2. 01	1. 63	1. 20
Age began cigarette smoking					
25 or older	*	2. 37	1. 70	1. 17	0. 96
15–24	*	3. 11	1. 99	1. 62	1. 36
<15	*	3. 47	2. 08	1. 54	*

*See footnote, table 4.

ex-cigarette smokers had high CHD death rates. This is discussed in another paper (*13*). Death rates went steadily down as the interval discontinuance increased. Men who had discontinued smoking for at least 1 year had lower death rates than current cigarette smokers; however, even after 10 years, the rates for former smokers of over 20 cigarettes a day did not reach the level prevailing for men who never smoked regularly.

CEREBRAL VASCULAR LESIONS

Other studies have indicated that death rates from cerebral vascular lesions (specified as the underlying cause) are not highly related to the smoking habits of men (*8*). Nevertheless, this disease is of considerable

TABLE 15b.—Coronary heart disease. Age-standardized death rates and mortality ratios of subjects with history of only cigarette smoking, by current number of cigarettes smoked per day, degree of inhalation, age began smoking, and age at start of study

Number of cigarettes per day, degree of inhalation, and age began smoking	Age				
	35–44	45–54	55–64	65–74	75–84
	CHD Death Rates per 100,000 Person-Years (Women)				
Current number of cigarettes per day					
1–9	*	31	206	719	*
10–19	*	66	268	927	*
20–39	*	88	328	1, 211	*
40+	*	*	*	*	*
Degree of inhalation					
None-slight	*	60	263	848	2, 236
Moderate-deep	*	71	308	1, 164	*
Age began cigarette smoking					
25 or older	*	66	283	887	2, 061
15–24	*	67	267	*	*
<15	*	*	*	*	*
Never smoked regularly	*	33	163	653	1, 973
	Mortality Ratios (Women)				
Current number of cigarettes per day					
1–9	*	0. 94	1. 26	1. 10	*
10–19	*	2. 00	1. 64	1. 42	*
20–39	*	2. 67	2. 01	1. 85	*
40+	*	*	*	*	*
Degree of inhalation					
None-slight	*	1. 82	1. 61	1. 30	1. 13
Moderate-deep	*	2. 15	1. 89	1. 78	*
Age began cigarette smoking					
25 or older	*	2. 00	1. 74	1. 36	1. 04
15–24	*	2. 03	1. 64	*	*
<15	*	*	*	*	*

*See footnote, table 4.

interest as the second leading cause of death among both men and women in this study. Since deaths from cerebral vascular lesions are far outnumbered by deaths attributed to coronary artery disease, all the death rates shown in tables 17 and 18 are less stable than the corresponding figures in tables 14 and 15. This statement applies particularly to death rates indicated with the symbol (†). Since cerebral vascular lesions are an infrequent cause of death among young people, the tables are confined to subjects between the ages of 55 and 84.

Pipe and cigar smoking appear to have little or no influence on death rates from cerebral vascular lesions (table 17). In age group 55 to 64, the CVL death rate was about 40 percent higher among men with a history of regular cigarette smoking compared to men who never smoked regularly. Similarly, in age group 65 to 74, the CVL death rate was 37 percent higher

TABLE 16.—Coronary heart disease (men). Age-standardized death rates for ex-cigarette smokers with history of cigarette smoking only, by former number of cigarettes smoked per day and years since last cigarette smoking. Death rates for current cigarette smokers with history of cigarette smoking only and men who never smoked regularly are shown for comparison. Men aged 50–69

Ex-cigarette smokers (years since last cigarette smoking)	Smoked 1–19 cigarettes a day			Smoked 20+ cigarettes a day		
	Number of men	Number of deaths	Death rate	Number of men	Number of deaths	Death rate
Under 1 year	746	27	1, 005†	2, 244	77	1, 070†
1–4 years	1, 844	51	718	5, 435	195	1, 003
5–9 years	1, 770	48	725	5, 803	152	732
10+ years	4, 209	84	498	8, 142	206	679
Total ex-smokers	8, 569	210	635	21, 624	630	813
Current cigarette smokers	22, 808	781	947	56, 886	1, 895	1, 029
Never smoked regularly	55, 728	1, 114	502	55, 728	1, 114	502

†Four or more but less than 10 deaths expected in some of the component 5-year age groups.

TABLE 17.—Cerebral vascular lesions. Age-standardized death rates, by type of smoking (lifetime history) and age at start of study

	Age			
	45–54	55–64	65–74	75–84
	CVL Death Rates per 100,000 Person-Years			
Men				
Never smoked regularly	28	92	349	1, 358
Pipe, cigar	25	100	369	1, 371
Cigarette and other	28	129	361	990
Cigarette only	42	130	477	1, 168
Total	35	116	391	1, 272
Women				
Never smoked regularly	18	57	228	1, 082
Cigarette	38	88	315	1, 277
Total	25	64	238	1, 091
	CVL Mortality Ratios			
Men				
Never smoked regularly	1. 00	1. 00	1. 00	1. 00
Pipe, cigar	0. 89	1. 09	1. 06	1. 01
Cigarette and other	1. 00	1. 40	1. 03	0. 73
Cigarette only	1. 50	1. 41	1. 37	0. 86
Women				
Never smoked regularly	1. 00	1. 00	1. 00	1. 00
Cigarette	2. 11	1. 54	1. 38	1. 18

among men with a history of only cigarette smoking. In age group 75 to 84, the CVL death rate was a little lower among men with a history of cigarette smoking than among those never smoking regularly. There was a similar pattern in women, but the mortality ratios for female cigarette

smokers were slightly higher than for males. This is the only disease to which this statement applies.

Table 18 shows CVL death rates of current cigarette smokers with a history of only cigarette smoking. As indicated by the symbols († and ‡) many of the death rates are quite unstable statistically, which may account for the irregular pattern of mortality ratios. Among male cigarette smokers, there is no clear relationship between death rates and any of the three exposure variables. Among female cigarette smokers, death rates appear to increase with each of the three variables, but the instability of the death rates precludes drawing firm conclusions on the matter.

Table 18.—Cerebral vascular lesions. Age-standardized death rates and mortality ratios, by current number of cigarettes smoked per day, degree of inhalation, and age began smoking, by age at start of study

Number of cigarettes per day, degree of inhalation, and age began smoking	MEN Age				WOMEN Age			
	45–54	55–64	65–74	75–84	45–54	55–64	65–74	75–84
	CVL Death Rates per 100,000 Person-Years							
Current number of cigarettes a day:								
1–9	‡	131†	468	873†	20†	64†	214†	1,740†
10–19	31	131	491	1,043†	45	112†	292†	‡
20–39	50	164	485	1,425†	48	98†	374†	‡
40+	71†	127†	‡	‡	‡	‡	‡	‡
Degree of inhalation:								
None-slight	59†	124	489	1,151	32	84	264	995†
Moderate-deep	46	162	483	1,393†	47	94	338†	‡
Age began cigarette smoking:								
25 or older	‡	152†	429	1,662†	34†	83	265	1,151
15–24	49	148	500	1,052†	44	91†	‡	‡
<15	61†	125†	481†	‡	‡	‡	‡	‡
	CVL Mortality Ratios							
Current number of cigarettes a day:								
1–9	‡	1.42†	1.34	0.64†	1.11†	1.12†	0.94†	1.61†
10–19	1.11	1.42	1.41	0.77†	2.50	1.96†	1.28†	‡
20–39	1.78	1.78	1.39	1.05†	2.67	1.72†	1.64†	‡
40+	2.54†	1.38†	‡	‡	‡	‡	‡	‡
Degree of inhalation:								
None-slight	2.11†	1.35	1.40	0.85	1.78	1.47	1.16	0.92†
Moderate-deep	1.64	1.76	1.38	1.03†	2.61	1.65	1.48†	‡
Age began cigarette smoking:								
25 or older	‡	1.65	1.23	1.22†	1.89†	1.46	1.16	1.06†
15–24	1.75	1.61	1.43	0.77†	2.44	1.60†	‡	‡
<15	2.18†	1.36	1.38†	‡	‡	‡	‡	‡

†Four or more but less than 10 deaths expected in the component 5-year age group.
‡Less than 4 deaths expected in the component 5-year age group.

LUNG CANCER—MEN

Physicians gave information concerning 1,021 of the 1,159 male deaths reportedly due to lung cancer (specified as the underlying cause of death). The diagnosis of cancer was known to have been confirmed by autopsy, surgical specimen, or biopsy for 854 of the 1,021 deaths. Most of the remaining 167 cases were diagnosed on the basis of clinical and X-ray evidence, although some included positive cytologic findings. Information on histologic type of the neoplasm was provided in 832 cases. These were classified as follows: 30 alveolar cell carcinoma; 5 mucinous cell carcinoma; 5 papillary adenocarcinoma; 128 adenocarcinoma; 6 mucoepidermoid carcinoma; 1 transitional cell carcinoma; 254 squamous cell carcinoma; 62 oat cell carcinoma; 166 undifferentiated carcinoma; 171 carcinoma (or bronchogenic carcinoma), not otherwise specified; 2 fibrosarcoma; 1 leiomysarcoma; and 1 sarcoma, not otherwise specified.

In most of the 1,021 deaths, the diagnosis of primary lung cancer was confirmed by histologic examination of a lung specimen. In a few cases, the physician expressed some uncertainty as to the primary site of the neoplásm. For the remaining 138 cases, we have at our disposal only information from the death certificates.

It may be that a few of the 1,159 deaths attributed to lung cancer were due to cancer of some other primary site; perhaps some were due to a pulmonary disease other than lung cancer. Even so, the evidence would indicate that most of these men (probably nearly all) actually died of cancer originating in the lungs. We considered excluding the 4 deaths from sarcoma, but decided not to do so since the distinction between sarcoma and carcinoma could not be made for the cases of unspecified histologic type.

Table 19 includes all 1,159 men reported to have died from lung cancer. The lung cancer death rates of men who smoked only pipes or only cigars were considerably higher than the rates for men who never smoked regularly, but low compared with the rates for cigarette smokers. Men with a history of only cigarette smoking had higher lung cancer death rates than men with a history of use of cigarettes in combination with another type. The mortality ratios of men with a history of only cigarette smoking increased with advancing age: 7.17 in age group 35 to 54, 9.84 in group 55 to 69, and 10.67 in group 70 to 84.

Table 20 shows the lung cancer death rates of current cigarette smokers with a history of only cigarette smoking by current number of cigarettes smoked per day, degree of inhalation, and age began smoking; the death rates increased with each of these variables.

Men who never smoked regularly had very low lung cancer death rates; these rates are based on a small number of deaths and are subject to considerable sampling variation. Therefore, the mortality ratios shown in tables 19 and 20 are subject to considerable sampling variation. Nevertheless, they are of interest. For men who currently smoked 40 or more cigarettes a day, the mortality ratio was 7.67 in age group 35 to 54, 17.47

TABLE 19.—Lung cancer (men). Number of deaths, and age-standardized death rates and mortality ratios, by type of smoking (lifetime history) and age at start of study

Type of smoking (lifetime history)	Age 35–54 Number of deaths	Age 35–54 Death rate	Age 55–69 Number of deaths	Age 55–69 Death rate	Age 70–84 Number of deaths	Age 70–84 Death rate	All ages, 35–84 Number of deaths	All ages, 35–84 Death rate
Never smoked regularly	11	6	27	19	11	25	49	12
Pipe only	1	4	11	50	9	95	21	27
Pipe and cigar	0	—	4	15	7	75	11	11
Cigar only	3	11	13	32	7	60	23	22
Cigarette and other	75	35	196	138	65	276	336	89
Cigarette only	219	44	432	188	68	270	719	111
Total	309	32	683	113	167	138	1, 159	68
			Lung Cancer Mortality Ratios (Men)					
Never smoked regularly		1. 00		1. 00		1. 00		1. 00
Pipe only		0. 68		2. 63		3. 74		2. 24
Pipe and cigar		—		0. 78		2. 95		0. 90
Cigar only		1. 84		1. 68		2. 39		1. 85
Cigarette and other		5. 76		7. 22		10. 90		7. 39
Cigarette only		7. 17		9. 84		10. 67		9. 20

Note: Mortality ratios are based on death rates carried to one more significant figure than shown.

in age group 55 to 69, and 29.84 in age group 70 to 84. For men who inhaled deeply, the respective mortality ratios were 9.00, 13.93, and 25.26; for men who began cigarette smoking before age 15 the mortality ratios were 12.80, 15.81, and 16.76, respectively.

Table 21 shows lung cancer death rates for male ex-cigarette smokers aged 50 to 69. Those who had stopped smoking for less than a year had very high death rates (*13*). Those who had stopped smoking for 1 year or longer had lower death rates than current cigarette smokers. Those who had stopped smoking for 10 years or longer had death rates no higher than those of men who never smoked regularly. It should be noted that the lung cancer death rates of the ex-cigarette smokers are based on small numbers and are subject to considerable sampling variation. However, the general picture is quite clear.

LUNG CANCER—WOMEN

Only 210 of the women were reported to have died of lung cancer (specified as the underlying cause of death) and physicians have sent further information on 179. Information on histologic type was provided on 134 cases as follows: 15 alveolar cell carcinoma, 1 mucinous cell carcinoma, 1 papillary adenocarcinoma, 32 adenocarcinoma, 30 squamous cell carcinoma, 16 oat cell carcinoma, 22 undifferentiated carcinoma, 16 carcinoma (or bronchogenic carcinoma), not otherwise specified, and 1 leiomyosarcoma.

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TABLE 20.—Lung cancer (men). Number of deaths, and age-standardized death rates and mortality ratios, by current number of cigarettes smoked per day, degree of inhalation, and age began smoking, by age at start of study

Number of cigarettes a day, degree of inhalation, and age began smoking	Age 35–54		Age 55–69		Age 70–84		All ages, 35–84	
	Number of deaths	Death rate	Number of deaths	Death rate	Number of deaths	Death rate	Number of deaths	Death rate
Current number of cigarettes a day								
1–9	9	38	12	68	5	134	26	56
10–19	15	24	57	168	10	243	82	90
20–39	138	58	216	264	27	446	381	159
40+	26	47	50	334	6	754	82	201
Degree of inhalation								
None or slight	19	29	87	203	14	193	120	102
Moderate	114	52	177	224	20	401	311	138
Deep	55	55	73	266	13	638	141	173
Age began cigarette smoking								
25 or older	5	17	12	65	3	85	20	39
20–24	31	36	72	212	7	306	110	118
15—19	112	54	176	250	27	490	315	155
<15	35	79	57	302	9	424	101	183
Never smoked regularly	11	6	27	19	11	25	49	12
	Lung Cancer Mortality Ratios (Men)							
Current number of cigarettes a day								
1–9		6.17		3.53		5.32		4.60
10–19		3.90		8.77		9.62		7.48
20–39		9.37		13.82		17.62		13.14
40+		7.67		17.47		29.84		16.61
Degree of inhalation								
None or slight		4.75		10.60		7.65		8.42
Moderate		8.48		11.72		15.88		11.45
Deep		9.00		13.93		25.26		14.31
Age began cigarette smoking								
25 or older		2.77		3.39		3.38		3.21
20–24		5.83		11.11		12.11		9.72
15–19		8.71		13.06		19.37		12.81
<15		12.80		15.81		16.76		15.10

Note: Mortality ratios are based on death rates carried out to one more significant figure than shown.

TABLE 21.—Lung cancer (men). Age-standardized death rates for ex-cigarette smokers with a history of cigarette smoking only, by former number of cigarettes smoked per day, and years since last cigarette smoking. Death rates for current cigarette smokers with a history of cigarette smoking only. Men who never smoked regularly are shown for comparison. Men aged 50–69

Ex-cigarette smokers (years since last cigarette smoking)	Smoked 1–19 cigarettes a day			Smoked 20+ cigarettes a day		
	Number of men	Number of deaths	Death rate	Number of men	Number of deaths	Death rate
Under 1 year	746	3	108	2,244	33	437
1–4 years	1,844	5	69	5,435	33	180
5–9 years	1,770	1	15	5,803	22	108
10+ years	4,209	1	6	8,142	5	16
Total ex-smokers	8,569	10	30	21,624	93	119
Current cigarette smokers	22,808	80	97	56,886	351	205
Never smoked regularly	55,728	32	15	55,728	32	15

As a first question, we wished to know whether lung cancer death rates differed between male and female nonsmokers. Table 22 is confined to subjects who never smoked regularly. Not a single lung cancer death was reported in age group 35 to 44 for subjects who never smoked regularly. The first and second columns of the table show the number of lung cancer deaths and the death rates by 5-year age groups for both sexes combined. The expected number of lung cancer deaths for male and female nonsmokers (under the null hypothesis that the two sexes are alike) were computed by applying the death rate for the two sexes combined to the separate schedules of person-years experience for men and women who never smoked regularly. (The person-years are shown in Appendix tables 2a and 2b.)

TABLE 22.—Lung cancer. Death rates per 100,000 person-years and observed and expected number of lung cancer deaths among men and women who never smoked regularly

Age group	Total men and women		Male deaths		Female deaths	
	Number of deaths	Death rate	Observed	Expected	Observed	Expected
40–44	4	2.3	2	0.6	2	3.4
45–49	16	5.0	4	3.5	12	12.5
50–54	16	4.9	5	3.3	11	12.7
55–59	30	10.5	5	6.0	25	24.0
60–64	32	13.9	14	6.2	18	25.8
65–69	26	14.7	8	5.2	18	20.8
70–74	18	16.1	2	3.8	16	14.2
75–79	21	35.8	7	4.6	14	16.4
80–84	14	54.6	2	2.7	12	11.3
Total	177	—	49	35.9	128	141.1

Altogether, 49 and 128 lung cancer deaths were reported ("observed") among men and women, respectively, who never smoked regularly. Among men, the observed number of deaths (49) exceeded the expected number (35.9), while among women the observed number (128) was less than the expected number (141.1). The probability is only about 1 in 100 that a difference of this size or greater would occur by chance alone. It appears that, among persons who never smoked regularly, men have a higher lung cancer death rate than women.

The age groups and smoking habits of the 210 women who died of lung cancer were as follows: (*a*) 35 to 39: none; (*b*) 40 to 54: 25 never smoked regularly, 43 current cigarette smokers, and 5 ex-cigarette smokers; (*c*) 55 to 74: 77 never smoked regularly, 27 current cigarette smokers, and 6 ex-cigarette smokers; (*d*) 75 to 84: 26 never smoked regularly and 1 ex-cigarette smoker. All the current cigarette smokers stated their current amount of smoking and degree of inhalation, but 1 did not state age began.

Table 23 summarizes the findings in age groups 40 to 54 and 55 to 74 and in the composite, 40 to 74. The lung cancer death rate was somewhat over twice as high for women with a history of cigarette smoking than for women who never smoked regularly. The rates were much higher for

current cigarette smokers using 20 or more cigarettes a day, who inhaled moderately or deeply, or began smoking before age 25. For those smoking 20 or more cigarettes a day, the mortality ratio was 4.43 in age group 40 to 54 and 4.91 in group 55 to 74.

TABLE 23.—Lung cancer (women). Number of deaths, age-standardized death rates, and mortality ratios, by type of smoking (lifetime history), current number of cigarettes smoked per day, degree of inhalation, and age began smoking, by age at start of study

Type of smoking (lifetime history)	Age 40–54 Number of deaths	Age 40–54 Death rate	Age 55–74 Number of deaths	Age 55–74 Death rate	All ages, 40–74 Number of deaths	All ages, 40–74 Death rate
Never smoked regularly	25	4	77	12	102	7
History of cigarette smoking	48	11	33	23	81	16
	Current Regular Cigarette Smoking					
Current number of cigarettes a day						
1–19	15	8	5	7	20	8
20+	28	17	22	59	50	35
Degree of inhalation						
None or slight	16	13	9	13	25	13
Moderate or deep	27	11	18	48	45	27
Age began smoking						
25 or older	7	6	16	21	23	12
<25	35	14	11	43	46	27
	Lung Cancer Mortality Ratios (Women)					
Never smoked regularly		1.00		1.00		1.00
History of cigarette smoking		2.82		1.93		2.20
	Current Regular Cigarette Smoking					
Current number of cigarettes a day						
1–19		2.08		0.62		1.06
20+		4.43		4.91		4.76
Degree of inhalation						
None or slight		3.33		1.12		1.78
Moderate or deep		2.90		4.04		3.70
Age began smoking						
25 or older		1.55		1.76		1.70
<25		3.78		3.60		3.65

Note: Mortality ratios are based on death rates carried out to one more significant figure than shown.

OTHER UNDERLYING CAUSES OF DEATH—MEN

Table 24 shows death rates from each of various underlying causes of death in two groups: men who never smoked regularly and men with a history of regular cigarette smoking. The latter includes both men with a history of only cigarette smoking and men with a history of cigarette and other smoking. The age groups are 45 to 64 and 65 to 79.

For many different diseases, the death rate of men with a history of cigarette smoking exceeded that of men who never smoked regularly. Considering the two age groups together, the following 7 diseases displayed

the highest mortality ratios: lung cancer, emphysema, cancer of the larynx, cancer of the buccal cavity and pharynx, aortic aneurysm, gastric ulcer, and cancer of the esophagus. These 7 diseases showed mortality ratios in excess of 4.00 in one or both age groups. Four other specific diseases exhibited mortality ratios above 2.50 in one or the other of the two age groups: cancer of the bladder, pancreas, and liver, and duodenal ulcer. For cirrhosis of the liver, the mortality ratio was about 2.00 in both age groups

The category "other heart diseases" includes myocardial degeneration, endocarditis, certain ill-defined heart diseases, and a few deaths from cor pulmonale. It showed a mortality ratio of 2.71 in age group 45 to 64 but only 1.09 in group 65 to 79. The category "other pulmonary diseases" includes pulmonary tuberculosis, asthma, pulmonary fibrosis, bronchiectasis, atelectasis, and miscellaneous other pulmonary diseases. It showed a mortality ratio above 2.25 in both age groups.

Table 25, confined to men in age group 55 to 84, shows death rates from each of various diseases for two groups: men who never smoked regularly and men with a history of pipe or cigar smoking who never smoked cigarettes regularly. The death rates from cancer of the buccal cavity and pharynx, larynx, and esophagus were far higher for pipe and cigar smokers than for men who never smoked regularly. These findings are based on a small number of deaths, but are in accord with previous studies. The death rates from lung cancer and gastric ulcers were each about twice as high for pipe and cigar smokers as for men who never smoked regularly. Other than this, the rates of pipe and cigar smokers (as a combined group) did not differ greatly from those of men who never smoked regularly.

OTHER UNDERLYING CAUSES OF DEATH—WOMEN

As shown in tables 5, 6, and 7, the death rates of women who were "light" cigarette smokers differed very little from the rates of women who never smoked regularly. These "light" cigarette smokers smoked very few a day, a moderate number a day with little or no inhalation, or had smoked for only a few years. Women who smoked more than "lightly" had higher death rates than women who never smoked regularly. How to distinguish between the "light smokers" and the "not so light smokers" is a problem, since at least two if not all three of the exposure variables enter into the picture (*see* tables 8 and 9). On the basis of data in table 8, we decided to separate a class designated as "heavier" cigarette smokers, although relatively few of these women smoked as "heavily" as a large proportion of all male cigarette smokers. The "heavier" cigarette smokers are identified as current cigarette smokers who: (*a*) smoked 20 or more a day regardless of age began smoking or (*b*) smoked 10 or more and began smoking before age 25.

Table 26 shows death rates from each of various underlying causes of death for women aged 45 to 64 who never smoked regularly, for all

TABLE 24.—Men, number of deaths, age-standardized death rates, and mortality ratios, by underlying cause of death. Men who never smoked regularly compared with men with history of cigarette smoking

Underlying cause of death	Age 45–64					Age 65–79				
	Never smoked regularly		History cigarette smoking			Never smoked regularly		History cigarette smoking		
	Number of deaths	Death rate	Number of deaths	Death rate	Mortality ratio	Number of deaths	Death rate	Number of deaths	Death rate	Mortality ratio
Cancer (total)	323	125	2, 172	267	2. 14	414	555	1, 119	973	1. 76
Lung (excl. trachea, pleura)	28	11	707	87	7. 84	17	23	312	262	11. 59
Buccal cavity, pharynx	2	1	63	8	9. 90	5	7	25	20	2. 93
Larynx	2	1	32	4	6. 09	1	2	18	14	8. 99
Esophagus	3	1	32	4	4. 17	3	4	8	7	1. 74
Bladder and other urinary	10	4	59	7	2. 00	13	17	56	50	2. 96
Kidney	11	4	54	6	1. 42	11	15	28	23	1. 57
Prostate	24	9	71	9	1. 04	93	122	131	123	1. 01
Pancreas	19	7	158	19	2. 69	22	31	75	66	2. 17
Liver, biliary passages	7	2	56	7	2. 84	11	14	22	19	1. 34
Stomach	29	11	131	16	1. 42	44	57	79	72	1. 26
Colon, rectum	81	32	265	33	1. 01	81	109	145	128	1. 17
Leukemia	22	9	100	12	1. 40	23	31	57	51	1. 68
Lymphoma, Hodgkin's disease	27	11	118	15	1. 38	39	55	52	44	0. 80
Other specified sites	42	16	220	27	1. 64	32	43	59	49	1. 14
Cancer—site not specified	16	6	106	13	2. 23	19	25	52	45	1. 78
Heart and Circulatory (total)	1, 083	422	6, 521	802	1. 90	1, 858	2, 471	3, 642	3, 238	1. 31
Coronary heart disease	781	304	5, 025	615	2. 03	1, 187	1, 586	2, 445	2, 159	1. 36
Rheumatic heart disease	47	19	158	19	0. 99	20	27	27	23	0. 85
Hypertensive heart disease	42	16	184	23	1. 40	73	96	149	136	1. 42
Other heart disease	30	12	262	33	2. 71	124	166	196	181	1. 09
Aortic aneurysm (nonsyphilitic)	18	7	140	18	2. 62	18	24	138	118	4. 92
Cerebral vascular lesions	137	53	590	74	1. 38	348	456	540	485	1. 06
Other circulatory diseases	28	11	162	20	1. 80	88	116	147	136	1. 18
Other Diseases (total)	231	91	1, 297	159	1. 76	321	431	844	758	1. 77
Emphysema	10	4	194	24	6. 55	10	13	175	153	11. 41
Pneumonia, influenza	17	7	101	13	1. 86	54	70	127	120	1. 72
Other pulmonary diseases	15	6	126	15	2. 68	25	34	84	77	2. 26

Gastric ulcer	6	2	53	7	2. 95	5	7	30	26	4. 06
Duodenal ulcer	7	3	60	7	2. 86	15	21	33	31	1. 50
Cirrhosis of liver	22	9	157	19	2. 06	11	16	39	31	1. 97
Nephritis and other kidney diseases	28	11	98	12	1. 08	34	45	53	47	1. 05
Diabetes	27	10	94	11	1. 11	39	52	61	55	1. 05
Other specified diseases	91	36	374	46	1. 28	113	152	217	194	1. 28
Ill-defined diseases	8	3	40	5	1. 66	15	21	25	24	1. 18
Violence, accidents, suicide	149	60	600	72	1. 20	85	116	145	129	1. 11
Total death certificates received	1, 786	698	10, 590	1, 300	1. 86	2, 678	3, 573	5, 750	5, 098	1. 43
Death certificates not yet received	25	10	235	29	2. 78	52	69	112	98	1. 42
Grand total	1, 811	708	10, 825	1, 329	1. 88	2, 730	3, 642	5, 862	5, 196	1. 43

Note: Mortality ratios are based on death rates carried to one more significant figure than shown.

Men with a lifetime history of only cigarette smoking combined with men with a lifetime history of cigarettes and other smoking.

TABLE 25.—Men aged 55–84. Number of deaths, age-standardized death rates, and mortality ratios, by underlying cause of death. Men aged 55–84 who never smoked regularly compared with men with history of pipe and/or cigar smoking

	Never smoked regularly		History of pipe and/or cigar smoking		
Underlying cause of death	Number of deaths	Death rate	Number of deaths	Death rate	Mortality ratio
Cancer (total)	713	361	568	436	1.21
Lung	38	20	51	40	1.97
Buccal cavity; pharynx	6	3	20	15	4.94
Larynx	2	1	4	4	3.37
Esophagus	4	2	10	8	3.97
Colon; rectum	144	74	123	96	1.31
Other and unspecified sites	519	261	360	273	1.05
Heart and circulatory (total)	3,046	1,504	2,165	1,590	1.06
Coronary heart disease	1,974	988	1,410	1,063	1.08
Other heart diseases	350	171	245	175	1.02
Cerebral vascular lesions	550	262	402	274	1.05
Other circulatory diseases	172	83	108	77	0.94
Other diseases (total)	541	270	399	285	1.05
Emphysema	20	11	20	15	1.37
Gastric ulcers	10	5	16	11	2.04
Duodenal ulcers	24	12	14	11	0.92
Other and ill-defined diseases	487	243	349	249	1.02
Accidents, violence, suicide	162	86	114	90	1.05
Total death certificates received	4,462	2,221	3,246	2,401	1.08
Death certificates not yet received	75	36	75	56	1.55
Grand total	4,537	2,257	3,321	2,457	1.09

Note: Mortality ratios are based on death rates carried to one more significant figure than shown.

women with a history of regular cigarette smoking, and for "heavier" cigarette smokers, as defined above. It should be pointed out that many of the death rates are based on a small number of deaths so that they and the derivative mortality ratios are very unstable statistically. In general, the diseases showing high mortality ratios for male cigarette smokers also showed relatively high mortality ratios for female cigarette smokers (or at least for female "heavier" cigarette smokers). These included emphysema, aortic aneurysm, lung cancer, cancer of the pancreas, and cancer of the combined sites—buccal cavity, pharynx, larynx, and esophagus.

Cancer of the colon and rectum that indicated no association with cigarette smoking in men showed a negative association with cigarette smoking in women.

In age group 65 to 79, there were very few female "heavier" cigarette smokers, so their death rates for most diseases are extremely unstable statistically. For the sake of completeness, results for this age group are shown in Appendix table 19.

CONTRIBUTING CAUSES OF DEATH

In filling out a death certificate, the doctor is required to specify some one disease or injury as the underlying cause of death, and to record any other diseases or injuries he believes "contributed" to death. The distinction between "underlying" and "contributing" is easy to make in many cases, but is often extremely difficult when the patient had two or more serious diseases or injuries. Indeed, some authors believe that it is unrealistic even to attempt to do so.

In analyzing death rates from various causes in relation to smoking habits, any of the following procedures may be used: 1) classify each death only according to the underlying cause, 2) classify each death according to each and every disease and injury mentioned on the death certificate, or 3) classify each death according to each of the various combinations of diseases and injuries mentioned on the death certificate. There is little difference between 1) and 2) for diseases and injuries seldom recorded as contributing to death (*i.e.*, diseases, which, if mentioned, are usually recorded as the underlying cause of death). However, there could be a great difference for diseases frequently mentioned as contributing to death (as distinguished from the underlying cause). As a practical matter, procedure 3) can only be employed in relation to specific combinations of diseases occurring fairly often.

Table 27 shows the number of instances in which each of various diseases was recorded as the underlying cause of death and as a contributing cause. For simplicity, we will refer only to the data for men, although figures for both sexes are included in the table. Cancer of the prostate was recorded on 611 death certificates, on 450 (74%) as the underlying cause of death and in 161 (26%) as a contributing cause. Fifteen percent of the bladder cancers and 12 percent of the colon and rectum cancers were mentioned as only contributing to death. Cancers of other sites in men were recorded as the underlying cause of death in over 90 percent of the cases and as a contributing cause in less than 10 percent of the cases in which cancer was mentioned. In 70 cases where cancer of one primary site was mentioned as contributing to death, cancer of another primary site was recorded as the underlying cause. Thus, for sites other than the prostate, relatively few observations are omitted in an analysis restricted to cancers specified as the underlying cause of death.

Coronary heart disease was mentioned on 12,749 death certificates—on 11,556 (91%) as underlying and on 1,193 (9%) as contributing to death. Other heart diseases were mentioned more often as contributing to death. The most striking example in this respect was cor pulmonale, recorded as the underlying cause of only 21 deaths but as contributing to 224 deaths.

Cerebral vascular lesions were mentioned on 3,397 death certificates—on 2,227 (66%) as underlying and on 1,170 (34%) as contributing to death. Several diseases were mentioned more often as contributing to death than as the underlying cause: pulmonary embolism and phlebitis; emphysema;

TABLE 26.—Women aged 45–64. Number of deaths, age-standardized death rates and mortality ratios, by underlying cause of death. Women aged 45–64 who never smoked regularly compared with women with history of cigarette smoking and with "heavier" cigarette smokers

Underlying cause of death	Never smoked regularly		History of cigarette smoking			"Heavier" cigarette smokers		
	Number of deaths	Death rate	Number of deaths	Death rate	Mortality ratio	Number of deaths	Death rate	Mortality ratio
Cancer (total)	1, 888	197	844	201	1. 02	432	220	1. 12
Lung (excl. trachea, pleura)	66	7	64	15	2. 17	46	25	3. 63
Buc. cav., phar., lar., and esoph.	17	2	13	3	1. 79	10	6	3. 17
Pancreas	62	6	46	11	1. 81	29	16	2. 58
Colon; rectum	265	27	84	21	0. 78	35	18	0. 66
Breast	630	67	253	56	0. 83	120	52	0. 78
Uterus	163	17	79	20	1. 18	35	20	1. 17
Ovary	178	19	78	19	0. 99	40	21	1. 15
Leukemia, lymphoma, and Hodgkin's disease	158	16	67	18	1. 12	36	22	1. 35
Other and unspecified sites	349	36	160	38	1. 06	81	40	1. 11
Heart and circulatory (total)	1, 641	161	943	256	1. 58	479	292	1. 80
Coronary heart disease	857	83	523	148	1. 77	272	175	2. 10
Other heart diseases	357	36	145	38	1. 05	57	34	0. 93
Cerebral vascular lesions	332	33	223	57	1. 74	128	69	2. 09
Aortic aneurysm	11	1	12	4	3. 89	5	5	5. 14
Other circulatory diseases	84	8	40	9	1. 11	17	9	1. 05
All other diseases (total)	569	59	310	78	1. 34	161	88	1. 50
Cirrhosis of liver	43	5	43	10	2. 16	33	15	3. 25
Pneumonia; influenza	36	4	19	5	1. 28	12	7	1. 94
Emphysema	6	1	10	3	4. 89	7	5	7. 38
Other diseases	484	49	238	60	1. 22	109	61	1. 23
Accidents, violence, suicide	222	23	144	32	1. 41	83	38	1. 63

Total death certificates received	4, 320	441	2, 241	568	1. 29	1, 155	638	1. 45
Death certificates not yet received	117	12	65	16	1. 37	35	21	1. 75
Grand total	4, 437	453	2, 306	584	1. 29	1, 190	659	1. 45

Note: See text for definition of "heavier" cigarette smokers.
Mortality ratios are based on death rates carried out to one more significant figure than shown.

TABLE 27.—Number of deaths from selected "underlying" and "contributing" causes of death. Men and women aged 35–84

Disease	MEN			WOMEN		
	Underlying cause	Contributing cause	Total	Underlying cause	Contributing cause	Total
Cancer						
Lung	1, 159	76	1, 235	210	19	229
Bladder	169	30	199	68	8	76
Prostate	450	161	611	–	–	–
Colon; rectum	744	98	842	750	80	830
Breast	8	1	9	1, 318	126	1, 444
Uterus	–	–	–	401	49	450
All other	2, 359	212	2, 571	2, 137	139	2, 276
Heart disease						
Coronary	11, 556	1, 193	12, 749	4, 654	727	5, 381
Rheumatic	308	102	410	311	72	383
Hypertensive	577	546	1, 123	617	527	1, 144
Cor pulmonale [a]	21	224	245	11	46	57
All other	820	595	1, 415	592	457	1, 049
Circulatory diseases						
Cerebral vascular	2, 227	1, 170	3, 397	2, 010	1, 012	3, 022
Aortic aneurysm	355	89	444	86	29	115
Pul. embolism; phlebitis [b]	142	418	560	121	301	422
Other diseases						
Emphysema	425	523	948	48	69	117
Pul. fibrosis; bronchiectasis; atelectasis [c]	84	137	221	39	78	117
Gastric ulcer	114	97	211	36	36	72
Duodenal ulcer	141	133	274	46	33	79
Cirrhosis of liver	279	126	405	138	50	188
Nephritis and other kidney diseases	272	397	669	201	264	465
Diabetes	283	829	1, 112	359	692	1, 051

a: Cor pulmonale specified as such. This disease is included in International List No. 434.4.
b: International List No. 463–466.
c: Pulmonary fibrosis specified as such. This is included in International List No. 525. Bronchiectasis, List No. 526, and atelectasis and pulmonary collapse, List No. 527.0.

pulmonary fibrosis, bronchiectasis, and atelectasis; nephritis, nephrosis, and other kidney diseases; and diabetes. Gastric ulcers, duodenal ulcers, and cirrhosis of the liver were also frequently mentioned as contributing to death.

Table 28 shows death rates from each of several diseases frequently stated as contributing to death based on the total number of death certificates on which the disease was mentioned, *i.e.*, underlying or contributing combined. Two groups of men are shown: men who never smoked regularly and men with a history of regular cigarette smoking ("cigarette only" and "cigarette and other" combined). This table may be compared with table 24 that reported on underlying causes of death only. With few exceptions, the findings expressed in terms of mortality ratios in these two tables are similar. That is, estimation of the relationship between

Table 28.—Men. Number of deaths, and age-standardized death rates and mortality ratios, by underlying and contributing cause of death combined. Men who never smoked regularly compared with men with history of cigarette smoking

Underlying and contributing cause of death	Age 45–64					Age 65–79				
	Never smoked regularly		History of cigarette smoking			Never smoked regularly		History of cigarette smoking		
	Number of deaths	Death rate	Number of deaths	Death rate	Mortality ratio	Number of deaths	Death rate	Number of deaths	Death rate	Mortality ratio
Cancer of prostate	28	10	89	11	1. 14	124	161	192	180	1. 12
Rheumatic heart disease	62	25	208	25	1. 01	29	39	43	36	0. 91
Hypertensive heart disease	87	34	383	47	1. 41	133	178	276	247	1. 39
Cor pulmonale [a]	13	5	120	15	2. 82	7	10	80	69	7. 25
Miscellaneous heart diseases	66	26	460	57	2. 17	183	243	348	318	1. 31
Cerebral vascular lesions	216	84	902	112	1. 34	513	675	893	814	1. 21
Aortic aneurysm	21	8	182	23	2. 86	24	32	172	149	4. 70
Pul. embolism; phlebitis [b]	59	23	189	23	1. 01	83	112	126	113	1. 01
Pulmonary emphysema	21	8	370	47	5. 94	31	42	433	381	9. 00
Pul. fibrosis; bronchiectasis; atelectasis [c]	11	4	99	12	2. 90	16	22	67	60	2. 69
Gastric ulcer	14	6	95	12	2. 15	12	16	50	44	2. 76
Duodenal ulcer	12	5	115	14	3. 02	26	35	73	65	1. 85
Cirrhosis of liver	33	13	222	27	1. 99	16	21	61	50	2. 33
Nephritis and other kidney diseases	52	20	229	28	1. 40	100	131	142	127	0. 97
Diabetes	99	38	373	46	1. 21	151	202	234	207	1. 02

a: Cor pulmonale specified as such. This disease is included in International List No. 434.4.

b: International List No. 463–466.

c: Pulmonary fibrosis specified as such. This is included in International List No. 525. Bronchiectasis, List No. 526, and atelectasis and pulmonary collapse, List No. 527.0.

Note: Mortality ratios are based on death rates carried out to one more significant figure than shown.

cigarette smoking and death rates for each of various diseases is not greatly affected by cause-of-death coding practices.

Three categories (cor pulmonale; embolism and phlebitis; and pulmonary fibrosis, bronchiectasis, and atelectasis) were so seldom mentioned as underlying causes of death that they were not shown separately in table 24; they were included with "other heart diseases," "other circulatory diseases," and "other pulmonary diseases," respectively. Table 28 indicates cor pulmonale and the lung diseases listed above to be strongly associated with cigarette smoking. Pulmonary embolism and phlebitis showed no such relationship.

The mortality ratio of cigarette smokers was somewhat higher for all duodenal ulcers (underlying and contributing combined) than for duodenal ulcers as underlying only. The opposite was found for gastric ulcers. Among men aged 45 to 64, the mortality ratio of cigarette smokers from nephritis and other kidney diseases was 1.08 for underlying and 1.40 for underlying plus contributing. Among men aged 65 to 79, the mortality ratio for cerebral vascular lesions is higher in table 28 than in table 24. With these exceptions, the mortality ratios shown in the two tables are remarkably similar.

In evaluation of the association between smoking habits and death rates attributed to a particular disease, it is of interest to know what other diseases have been mentioned by the certifying physicians. Table 29 shows the interrelationships among diseases specified as an underlying or contributing cause of death. Although the table covers both men and women, for simplicity we will confine remarks to findings for men.

Cancer of some particular site was specified as the underlying cause of 4,889 male deaths, and on 3,251 (66%) of these death certificates no other disease or injury was mentioned as contributing to death. Cancer of some other primary site was mentioned as a contributing cause of death on 70 of these 4,889 death certificates; some type of heart disease on 404; cerebral vascular lesions on 95; emphysema on 64, and diabetes on 73.

Coronary heart disease was specified as the underlying cause of 11,556 male deaths, and on 8,417 of these death certificates no contributing cause was mentioned. The principal contributing causes mentioned were diabetes, cerebral vascular lesions, hypertensive heart disease, cancer, and emphysema. In the other direction, coronary heart disease was the most common disease mentioned as contributing to death when either diabetes or cerebral vascular lesions were specified as the underlying cause. Considering the definition of cor pulmonale, it is not surprising to learn that emphysema was entered on 125 and pulmonary fibrosis, bronchiectasis, or atelectasis on 26 of the 245 death certificates in which the physicians made some reference to cor pulmonale in the certifications.

Of the several thousand possible causes of death, fewer than 100 currently account for all but a small proportion of adult deaths in the United States. In coding death certificates we therefore grouped various rare con-

TABLE 29.—Death certificates classified by contributing causes of death in relation to underlying cause of death. Men and women aged 35–84 at enrollment

Underlying cause	Net total	Contributing causes: Cancer	CHD	RHD	HHD	Cor pul.	Other HD	CVL	Emp.	Pul. fib.	Cirr. liv.	Diabetes	All other causes	No other causes
Men														
Cancer	4, 889	73	217	12	26	9	140	95	64	45	15	73	1, 256	3, 251
Coronary	11, 556	247	—	57	400	16	2	423	233	37	34	508	1, 833	8, 417
Rheumatic	308	4	65	—	0	0	1	14	3	0	3	1	88	157
Hypertensive	577	15	81	3	—	2	0	239	14	1	3	15	169	152
Cor pulmonale	21	0	1	0	0	—	5	0	6	1	0	0	15	3
Other heart disease	820	21	11	1	0	1	—	114	27	4	8	28	288	429
Cerebral vascular	2, 227	60	157	8	26	0	58	—	19	6	7	87	468	1, 477
Emphysema	425	26	46	2	7	119	69	17	—	11	3	2	187	92
Pul. fibrosis	84	2	11	2	1	25	21	2	6	—	0	2	37	18
Cirr. liver	279	8	20	4	3	1	12	5	4	1	—	13	164	104
Diabetes	283	4	157	0	14	1	22	49	3	0	6	—	93	17
All other causes	4, 426	118	427	13	69	50	265	212	144	31	47	100	1, 557	2, 172
Total	25, 895	578	1, 193	102	546	224	595	1, 170	523	137	126	829	6, 155	16, 289
Women														
Cancer	4, 884	97	141	10	41	1	131	100	6	19	11	77	956	3, 534
Coronary	4, 654	127	—	35	366	8	1	286	28	15	12	336	986	2, 827
Rheumatic	311	7	43	—	3	0	3	37	2	3	3	6	96	139
Hypertensive	617	22	64	3	—	0	0	262	1	1	1	49	146	192
Cor pulmonale	11	1	0	0	0	—	2	0	1	2	0	0	8	1
Other heart disease	592	20	4	1	0	3	—	102	8	1	2	31	231	280
Cerebral vascular	2, 010	40	104	9	42	0	70	—	2	5	4	96	434	1, 341
Emphysema	48	0	1	1	2	14	11	1	—	1	0	1	33	2
Pul. fibrosis	39	1	1	1	1	7	9	0	2	—	0	0	21	10
Cirr. liver	138	6	9	0	0	0	11	3	0	2	—	3	89	46
Diabetes	359	5	166	1	23	0	29	67	0	0	3	—	144	30
All other causes	2, 670	95	194	11	49	13	190	154	19	29	14	93	917	1, 284
Total	16, 333	421	727	72	527	46	457	1, 012	69	78	50	692	4, 061	9, 686

ditions in a residual category labeled "other diseases." Dorn did likewise in his prospective study of veterans (*9*). However, he assigned a special code number to Parkinson's disease (paralysis agitans), possibly at the suggestion of a mutual friend, Sir Ernest Kennaway (a leading investigator of chemical carcinogenesis), who was a victim of that disease. Kahn has analyzed the data from the Veterans Study and found a negative association between cigarette smoking and Parkinson's disease (*16*).

A personal communication from Kahn on this point led us to make a special review of our material. Parkinson's disease was mentioned on the death certificates of 123 men, being specified as the underlying cause of death on 51 certificates and as a contributing factor on 72. In age group 45 to 64, the death rate from this disease was 3.4 per 100,000 person-years for men who never smoked regularly and 2.6 per 100,000 person-years for men with a history of only cigarette smoking; in age group 65 to 79, the respective rates were 43.2 and 34.8. These rates are unstable statistically due to small numbers observed, but they appear in general agreement with Kahn's findings.

DISCUSSION

Findings in male subjects after 4 years of follow-up were not significantly different from those reported for the same subjects after 3 years of follow-up (*6*). However, with additional deaths, the death rates were somewhat more stable statistically and we could make more detailed analyses. We thought it unnecessary to repeat at this time the matched-pair analysis and the analysis in respect to various factors other than smoking included in the previous report (*6*). We plan similar analyses, but in greater detail, after the subjects have been traced for 2 more years.

The major new findings in this study concern the relationship between cigarette smoking and the death rates of women. Qualitatively, the association between cigarette smoking and total death rates, and death rates from various specific diseases, was essentially the same for women and men. Quantitatively, there was a sex difference that may be summarized as follows:

1) The total death rates of men who never smoked regularly were higher than the total death rates of women who never smoked regularly.
2) For both sexes, total death rates were higher in subjects with a history of cigarette smoking than in those who never smoked regularly. However, the percentage by which the death rate of cigarette smokers exceeded the death rate of nonsmokers was greater in men than in women, apparently because female cigarette smokers, as a group, smoked fewer cigarettes per day, inhaled less deeply, and started the habit later in life than males.

3) As a consequence of 1) and 2), the absolute difference between the death rate of cigarette smokers and the death rate of nonsmokers was far greater for men than for women.

What has been said concerning total death rates of men and women applies to death rates from most of the diseases found to be associated with cigarette smoking. Death rates from cerebral vascular lesions followed a different pattern. Among persons who never smoked regularly, death rates from this disease were higher in men than in women. However, the percentage excess in the CVL death rate of cigarette smokers over that of nonsmokers was greater for women than for men.

There has been considerable interest in whether the degree of relationship between cigarette smoking and death rates changes as people grow older. To answer this precise question it would be necessary to trace a cohort of people from youth through old age. This has not been done. However, we can inquire whether the difference between the death rates of people with a history of cigarette smoking and of people who never smoked regularly varies with age in a cross-section of the current population (*i.e.*, whether there is a difference in this respect between people who are now relatively young and people who are now old).

In both sexes, the difference in death rates between subjects with a history of only cigarette smoking and those who never smoked regularly increased greatly from age group 35 to 39 through group 80 to 84. The basic data are shown in Appendix tables 2a and 2b. For men, the differences (expressed in deaths per 100,000 person-years) in successive 5-year age groups were: 112, 205, 424, 548, 909, 1,173, 1,692, 1,987, 2,521, and 3,274 (age group 35–39 through 80–84). The corresponding figures for women were: 7, 27, 62, 127, 169, 215, 473, 763, 283, and 2,065. (The last 2 figures for women are subject to considerable sampling variation due to the small number of older women who smoke cigarettes.) This is consistent with evidence from histologic studies of lung, coronary artery, and esophageal tissues, which indicates that the damage done by cigarette smoking progresses so long as cigarette smokers continue the habit (*14*, *15*, *17–21*).

Cancer has been produced experimentally by the application of cigarette smoke condensates to the skin of experimental animals (*22*). This, together with histologic findings (*17–20*) of a very high degree of association between cigarette smoking and changes in the nuclei of cells in the epithelium of the bronchial tubes and esophagus, leaves no doubt as to the interpretation of findings in this and other epidemiological studies. Cigarette smoking can and often does cause cancer of these sites as well as cancer of the buccal cavity, pharynx, and larynx.

The decline in lung cancer death rates among ex-cigarette smokers (compared with current ones) is paralleled by findings of a decrease in the number of cells with atypical nuclei in the bronchial epithelium of ex-cigarette smokers (as compared with current ones) (*19*).

The very high degree of association found between cigarette smoking and death rates from pulmonary emphysema is paralleled by histologic

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findings of a very high degree of association between cigarette smoking and changes in the lung parenchyma including rupturing of alveolar septums, fibrosis, and an increase in thickness of the walls of small arteries and arterioles (*14*).

The association found in this and other studies between cigarette smoking and death rates from coronary heart disease is paralleled by histologic findings of a high association between cigarette smoking and the degree of atherosclerosis in the coronary arteries (*21*).

SUMMARY

This report is based on 3,764,571 person-years of experience and 43,221 deaths occurring among 1,003,229 subjects (440,558 men and 562,671 women) between the ages of 35 and 84 from October 1, 1959, to February 15, 1960, when they enrolled in a prospective study and answered detailed questionnaires including questions on their smoking habits.

Death rates of both men and women were higher among subjects with a history of cigarette smoking than among those who never smoked regularly. Death rates of current cigarette smokers increased with number of cigarettes smoked per day and degree of inhalation. Death rates were higher among current cigarette smokers starting the habit at a young age than among those starting the habit later in life. Among both men and women, the difference between the death rates of cigarette smokers and nonsmokers increased with age. Among men, the death rates for ex-cigarette smokers were lower than for men currently smoking cigarettes when they enrolled in the study. Death rates of ex-cigarette smokers decreased with the length of time since they last smoked cigarettes.

Among both men and women, death rates from the following diseases were much higher in cigarette smokers than in nonsmokers: emphysema; cancer of the lung; cancer of the buccal cavity, pharynx, larynx, and esophagus; aortic aneurysm; cancer of the pancreas; and cirrhosis of the liver. Among men, death rates from cancer of the bladder and from gastric and duodenal ulcers were also much higher in cigarette smokers.

Coronary heart disease accounted for 44.6 percent of the male deaths and 28.5 percent of the female deaths. In both sexes and in all age groups, the CHD death rate was higher in subjects with a history of cigarette smoking than in nonsmokers; in both sexes, the CHD death rate of current cigarette smokers increased with amount smoked. In age group 45 to 54, the CHD death rate of men with a history of only cigarette smoking was 2.81 times as high as that of men who never smoked regularly; the CHD death rate of women with a history of cigarette smoking was 2.00 times as high as that of women who never smoked regularly.

Cerebral vascular lesions accounted for 8.6 percent of the male deaths and 12.3 percent of the female deaths. In age group 45 to 54, the CVL death rate of men with a history of only cigarette smoking was 1.50 times higher than for men who never smoked regularly; the CVL death rate of

women with a history of cigarette smoking was 2.11 times higher than for women who never smoked regularly.

Total death rates and death rates from most of the common diseases occurring in both sexes were higher in men than women, were higher in men who never smoked regularly than in women who never smoked regularly, and were far higher in men with a history of cigarette smoking than in women with a history of regular cigarette smoking.

The difference between the death rates of subjects with a history of cigarette smoking and subjects who never smoked regularly was far greater among men than women. This statement applies to all causes combined and to most of the specific diseases found to be associated with cigarette smoking. Female cigarette smokers (as a group) have been far less exposed to cigarette smoke than male cigarette smokers of the same ages, as judged by number of cigarettes smoked per day, degree of inhalation, and the number of years they have smoked. Many female cigarette smokers smoke only a few cigarettes a day, do not inhale, and have been smoking for only a few years; their death rates are about the same as the death rates of women who never smoked regularly.

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APPENDIX

For a detailed study of death rates, one wishes to know the number of: subjects, person-years, and deaths on which the rates are based. These details are shown in Appendix tables in order to reduce the length and complexity of the text tables.

Appendix table 1 gives an over-all summary of the number of: subjects enrolled, person-years, and deaths for males and females by age at enrollment.

Since a few subjects were lost to follow-up, the number living and traced through September 30, 1963, was slightly less than the number enrolled minus the number known to have died. Person-years have been adjusted for deaths and loss to follow-up.

Most of the Appendix tables simply supplement the text tables. The correspondence between text tables and Appendix tables is:

Text table	Appendix table
3 and 4	2a and 2b
5	3a and 3b
6	4a and 4b
7	5a and 5b
8 and 9	6
10	7, 8, and 9
11	10
12	11
13	12
14	14
15a and 15b	15
16	16
17	17
18	18
26	19

3. Do you now smoke? Yes ☐ No ☐
   If "yes,": a) How many cigarettes do you usually smoke a day?__________
   b) How many cigars do you usually smoke a day?__________
   c) How many pipefuls of tobacco do you usually smoke a day?__________
4. If you now smoke cigarettes:
   a) About how much do you inhale when smoking cigarettes?
   Do not inhale ☐ Inhale Slightly ☐ Inhale Moderately ☐ Inhale Deeply ☐
   b) What type do you smoke? Filter-tip ☐ Without filter-tip ☐
   c) What brand do you usually smoke?____________________
   d) How old were you when you started smoking cigarettes?__________
5. If you now smoke cigars, about how much do you inhale when smoking cigars?
   Do Not Inhale ☐ Inhale Slightly ☐ Inhale Moderately ☐ Inhale Deeply ☐
6. If you now smoke a pipe, about how much do you inhale when smoking a pipe?
   Do Not Inhale ☐ Inhale Slightly ☐ Inhale Moderately ☐ Inhale Deeply ☐
7. If you <u>do not</u> smoke cigarettes now, did you ever smoke cigarettes regularly? Yes ☐ No ☐
   If "yes,": a) How long has it been since you last smoked cigarettes regularly?__________
   b) How many cigarettes did you usually smoke per day?__________
   c) Why did you stop smoking cigarettes?____________________
8. If you <u>do not</u> smoke cigars now, did you ever smoke cigars regularly? Yes ☐ No ☐
9. If you <u>do not</u> smoke a pipe now, did you ever smoke a pipe regularly? Yes ☐ No ☐
10. Do you chew tobacco or use snuff? Never ☐ Occasionally ☐ Regularly ☐

Appendix Figure 1. Questions on smoking habits - men

3. Do you now smoke? Yes ☐ No ☐
   If "yes,": a) How many cigarettes do you usually smoke a day?__________
   b) About how much do you inhale when smoking cigarettes?
   Do not inhale ☐ Inhale slightly ☐ Inhale moderately ☐ Inhale deeply ☐
   c) What type do you smoke? Filter-tip ☐ Without filter-tip ☐
   d) What brand do you usually smoke?____________________
   e) How old were you when you started smoking cigarettes?__________
4. If you do not smoke cigarettes now, did you ever smoke cigarettes regularly? Yes ☐ No ☐
   If "yes," a) How long has it been since you last smoked cigarettes regularly?__________
   b) How many cigarettes did you usually smoke per day?__________
   c) Why did you stop smoking cigarettes?____________________

Appendix Figure 2. Questions on smoking habits - women

AMERICAN CANCER SOCIETY

Family Number	Person Number	NAME:	Div. No.	Unit No.	Group No.	Res. No.

1. Have you been hospitalized at any time since October 1, 1959 ? Yes ☐ No ☐
   If "yes": a) Disease(s):
   b) Date(s):
2. Have you had a surgical operation since October 1, 1959? Yes ☐ No ☐
   If "yes": a) Type of operation(s):
   b) Date (s):
3. Have you ever had cancer? Yes ☐ No ☐
   If "yes": a) What type of cancer?
   b) Date of first treatment:
4. Have you had any other serious diseases since October 1. 1959? Yes ☐ No ☐
   If "yes": What diseases ? (OVER)

Appendix Figure 3. Supplementary questionnaire card - front

1. Home address: City__________ P.O. ZONE NO.____ State:______
2. Were you living here in 1959? Yes ☐ No ☐
3. Location of your home: In country ☐ Outskirts of town ☐ Center of town ☐
4. Is your home in an area with heavy air pollution from factories, power plants, refineries, etc.? Yes ☐ No ☐
5. Do you work in such an area (i.e., heavy air pollution)? Yes ☐ No ☐
6. How many hours a week are you in automobiles, buses, or trucks?______hours.
7. Do you now smoke cigarettes? Yes ☐ No ☐
   If yes: a) How many cigarettes do you usually smoke a day? ________
   b) What brand do you usually smoke?__________
8. Have you ever been vaccinated against: Smallpox? Yes ☐ No ☐
   Tetanus? Yes ☐ No ☐ Polio? Yes ☐ No ☐ Diphtheria? Yes ☐ No ☐ (OVER)

Appendix Figure 4. Supplementary questionnaire card - back

APPENDIX TABLE 1.—Number of subjects, number of deaths, and number of person-years of experience, by sex and age at start of study

Age	Number of subjects		Number of deaths		Number of person-years			
	Men	Women	Men	Women	Men	Women	Total: Number	Total: Percent
35–39	18, 253	36, 146	179	192	69, 120	137, 280	206, 400	5. 5
40–44	32, 016	73, 579	452	535	121, 154	280, 315	401, 469	10. 7
45–49	96, 347	116, 167	2, 038	1, 242	364, 802	442, 418	807, 220	21. 4
50–54	95, 220	105, 065	3, 259	1, 586	359, 151	400, 008	759, 159	20. 2
55–59	73, 095	81, 127	3, 937	1, 862	273, 242	307, 899	581, 141	15. 4
60–64	53, 317	60, 039	4, 490	2, 053	196, 587	226, 661	423, 248	11. 2
65–69	37, 077	43, 608	4, 445	2, 531	134, 234	162, 849	297, 083	7. 9
70–74	21, 171	26, 550	3, 680	2, 584	74, 405	97, 326	171, 731	4. 6
75–79	10, 124	13, 915	2, 511	2, 361	34, 152	49, 093	83, 245	2. 2
80–84	3, 938	6, 475	1, 457	1, 827	12, 364	21, 511	33, 875	0. 9
Total	440, 558	562, 671	26, 448	16, 773	1, 639, 211	2, 125, 360	3, 764, 571	100. 0

APPENDIX TABLE 2a.—Number of men, number of person-years, number of deaths, and death rates for men, by type of smoking and age at start of study

Type of smoking (lifetime history)	Age: 35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84
	Number of Men at Start									
Never smoked regularly	3, 492	6, 280	18, 424	18, 439	15, 273	12, 204	9, 812	6, 604	3, 727	1, 594
Pipe only	350	684	2, 013	2, 153	1, 873	1, 833	1, 818	1, 429	848	435
Pipe and cigar	347	658	1, 936	2, 460	2, 323	2, 217	2, 027	1, 495	861	374
Cigar only	509	877	2, 856	3, 595	3, 680	3, 488	2, 841	1, 831	1, 049	435
Cigarette and other	3, 432	6, 514	20, 281	21, 088	16, 891	12, 779	8, 838	4, 516	1, 728	550
Cigarette only	10, 123	17, 003	50, 837	47, 485	33, 055	20, 796	11, 741	5, 296	1, 911	550

Total	18, 253	32, 016	96, 347	95, 220	73, 095	53, 317	37, 077	21, 171	10, 124	3, 938
	Number of Person-Years									
Never smoked regularly	13, 269	23, 873	70, 213	70, 043	57, 748	45, 557	36, 135	23, 561	12, 824	5, 031
Pipe only	1, 326	2, 604	7, 683	8, 188	7, 073	6, 814	6, 636	5, 101	2, 936	1, 397
Pipe and cigar	1, 318	2, 501	7, 346	9, 351	8, 743	8, 276	7, 435	5, 330	2, 882	1, 199
Cigar only	1, 914	3, 313	10, 841	13, 633	13, 832	12, 949	10, 364	6, 536	3, 555	1, 375
Cigarette and other	13, 028	24, 667	76, 812	79, 467	63, 104	47, 087	31, 924	15, 733	5, 765	1, 729
Cigarette only	38, 266	64, 197	191, 906	178, 469	122, 743	75, 903	41, 741	18, 144	6, 190	1, 634
Total	69, 120	121, 154	364, 802	359, 151	273, 242	196, 587	134, 234	74, 405	34, 152	12, 365
	Number of Deaths									
Never smoked regularly	23	55	190	379	496	746	901	990	839	565
Pipe only	4	3	17	46	73	131	195	199	175	159
Pipe and cigar	2	5	31	46	82	130	204	231	226	135
Cigar only	7	11	37	83	151	261	290	267	257	155
Cigarette and other	34	99	430	762	965	1, 088	1, 108	870	453	206
Cigarette only	109	279	1, 333	1, 943	2, 170	2, 134	1, 747	1, 123	561	237
Total	179	452	2, 038	3, 259	3, 937	4, 490	4, 445	3, 680	2, 511	1, 457
	Death Rates per 100,000 Person-Years									
Never smoked regularly	173	230	271	541	859	1, 638	2, 493	4, 202	6, 542	11, 230
Pipe only	*	*	221	562	1, 032	1, 923	2, 939	3, 901	5, 960	11, 382
Pipe and cigar	*	*	422	492	938	1, 571	2, 744	4, 334	7, 842	11, 259
Cigar only	*	332	341	609	1, 092	2, 016	2, 798	4, 085	7, 229	11, 273
Cigarette and other	261	401	560	959	1, 529	2, 311	3, 471	5, 530	7, 858	11, 914
Cigarette only	285	435	695	1, 089	1, 768	2, 811	4, 185	6, 189	9, 063	14, 504
Total	259	373	559	907	1, 441	2, 284	3, 311	4, 946	7, 352	11, 784

See footnotes at end of Appendix tables.

APPENDIX TABLE 2b.—Number of women, number of person-years, number of deaths, and death rates for women, by type of smoking and age at start of study

Type of smoking (lifetime history)	Age									
	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84
	Number of Women at Start									
Never smoked regularly	18, 476	39, 125	65, 625	67, 952	60, 105	49, 048	37, 793	24, 072	12, 973	6, 200
Cigarette	17, 670	34, 454	50, 542	37, 113	21, 022	10, 991	5, 815	2, 478	942	275
Total	36, 146	73, 579	116, 167	105, 065	81, 127	60, 039	43, 608	26, 550	13, 915	6, 475
	Number of Person-Years									
Never smoked regularly	70, 342	149, 404	250, 469	259, 275	228, 492	185, 422	141, 372	88, 426	45, 801	20, 623
Cigarette	66, 938	130, 911	191, 949	140, 733	79, 407	41, 239	21, 477	8, 900	3, 292	888
Total	137, 280	280, 315	442, 418	400, 008	307, 899	226, 661	162, 849	97, 326	49, 093	21, 511
	Number of Deaths									
Never smoked regularly	96	266	636	912	1, 282	1, 607	2, 109	2, 286	2, 194	1, 734
Cigarette	96	269	606	674	580	446	422	298	167	93
Total	192	535	1, 242	1, 586	1, 862	2, 053	2, 531	2, 584	2, 361	1, 827
	Death Rates per 100,000 Person-Years									
Never smoked regularly	136	178	254	352	561	867	1, 492	2, 585	4, 790	8, 408
Cigarette	143	205	316	479	730	1, 082	1, 965	3, 348	5, 073	10, 473
Total	140	191	281	396	605	906	1, 554	2, 655	4, 809	8, 493

See footnotes at end of Appendix tables.

APPENDIX TABLE 3a.—Number of men, number of person-years, number of deaths, and death rates for men with history of only cigarette smoking, who were currently smoking cigarettes at time of enrollment, by current number of cigarettes smoked per day and age at start of study

Current number of cigarettes per day	Age									
	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84
	Number of Men at Start									
1–9	576	932	2, 609	2, 610	2, 085	1, 598	1, 098	653	300	97
10–19	1, 312	2, 158	6, 258	5, 914	4, 479	3, 117	1, 907	935	307	94
20–39	5, 367	8, 730	24, 957	21, 929	13, 956	7, 618	3, 651	1, 330	392	95
40+	1, 097	1, 987	5, 855	5, 192	2, 848	1, 238	454	142	29	7
	Number of Person-Years									
1–9	2, 166	3, 528	9, 853	9, 879	7, 818	5, 881	3, 944	2, 255	986	282
10–19	4, 958	8, 162	23, 658	22, 188	16, 630	11, 354	6, 740	3, 209	972	272
20–39	20, 314	32, 929	94, 126	82, 259	51, 715	27, 645	12, 904	4, 553	1, 280	293
40+	4, 120	7, 477	21, 977	19, 428	10, 432	4, 485	1, 605	473	93	20
	Number of Deaths									
1–9	5	14	63	84	102	148	155	135	85	45
10–19	11	26	165	252	299	334	313	193	98	48
20–39	57	154	709	987	992	871	588	303	114	37
40+	17	46	192	264	246	140	78	33	8	3
	Death Rates per 100,000 Person-Years									
1–9	*	397	639	850	1, 305	2, 517	3, 930	5, 987	8, 621	15, 957
10–19	222	319	697	1, 136	1, 798	2, 942	4, 644	6, 014	10, 082	17, 647
20–39	281	468	753	1, 200	1, 918	3, 151	4, 557	6, 655	8, 906	12, 628
40+	413	615	874	1, 359	2, 358	3, 122	5, 860	6, 977	*	*

See footnotes at end of Appendix tables.

Appendix table 3b.—Number of women, number of person-years, number of deaths, and death rates for women, who were currently smoking cigarettes at time of enrollment, by current number of cigarettes smoked per day and age at start of study

Current number of cigarettes per day	Age 35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84
	Number of Women at Start									
1–9	3, 425	6, 602	9, 866	7, 857	4, 915	2, 877	1, 669	795	295	103
10–19	4, 455	8, 903	13. 566	9. 767	5. 394	2, 666	1, 375	553	208	47
20–39	6, 489	12, 486	17, 423	12, 098	6, 341	2, 955	1, 352	467	152	32
40+	603	984	1, 434	1, 034	515	198	88	23	5	0
	Number of Person-Years									
1–9	13, 020	25, 151	37, 571	29, 924	18, 612	10, 866	6, 230	2, 885	1, 054	327
10–19	16, 863	33, 892	51, 610	37, 081	20, 376	10, 011	5, 085	1, 991	726	147
20–39	24, 559	47, 368	66, 019	45, 747	23, 910	11, 016	4, 984	1, 655	529	108
40+	2, 255	3, 718	5, 399	3, 893	1, 943	747	315	89	17	0
	Number of Deaths									
1–9	17	39	86	105	112	86	101	81	45	36
10–19	27	54	150	167	151	113	91	60	38	17
20–39	38	121	242	259	185	147	105	69	23	9
40+	1	14	32	23	16	7	11	0	2	0
	Death Rates per 100,000 Person-Years									
1–9	131	155	229	351	602	791	1, 621	2, 808	4, 269	11, 009
10–19	160	159	291	450	741	1, 129	1, 790	3, 014	5, 234	11, 565
20–39	155	255	367	566	774	1, 334	2, 107	4, 169	4, 348	*
40+	*	*	593	591	823	*	*	*	*	*

See footnotes at end of Appendix tables.

APPENDIX TABLE 4a.—Number of men, number of person-years, number of deaths, and death rates for men with history of only cigarette smoking, who were currently smoking cigarettes at time of enrollment, by degree of inhalation and age at start of study

Degree of inhalation	Age									
	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84
	Number of Men at Start									
None	234	430	1, 502	1, 885	1, 717	1, 392	978	569	232	74
Slight	828	1, 459	4, 307	4, 397	3, 655	2, 590	1, 584	760	277	94
Moderate	4, 614	7, 896	23, 065	20, 390	12, 780	7, 066	3, 501	1, 280	376	87
Deep	2, 668	4, 017	10, 760	8, 950	5, 137	2, 514	1, 054	435	128	39
	Number of Person-Years									
None	887	1, 622	5, 672	7, 118	6, 414	5, 109	3, 526	2, 012	763	234
Slight	3, 101	5, 518	16, 257	16, 562	13, 556	9, 433	5, 625	2, 636	884	283
Moderate	17, 465	29, 789	86, 991	76, 493	47, 382	25, 742	12, 403	4, 349	1, 244	250
Deep	10, 078	15, 152	40, 520	33, 501	18, 953	9, 056	3, 663	1, 435	386	100
	Number of Deaths									
None	1	10	42	65	102	115	125	96	63	28
Slight	11	20	112	172	249	294	254	156	88	42
Moderate	44	145	659	921	889	761	556	292	98	41
Deep	33	65	317	427	390	322	198	117	53	23
	Death Rates per 100,000 Person-Years									
None	*	*	740	913	1, 590	2, 251	3, 545	4, 771	8, 257	11, 966
Slight	*	362	689	1, 039	1, 837	3, 117	4, 516	5, 918	9, 955	14, 841
Moderate	252	487	758	1, 204	1, 876	2, 956	4, 483	6, 714	7, 878	16, 400
Deep	327	429	782	1, 275	2, 058	3, 556	5, 405	8, 153	13, 731	23, 000

See footnotes at end of Appendix tables.

APPENDIX TABLE 4b.—Number of women, number of person-years, number of deaths, and death rates for women, who were currently smoking cigarettes at time of enrollment, by degree of inhalation and age at start of study

Degree of inhalation	Age									
	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84
	Number of Women at Start									
None	983	2, 070	3, 921	4, 455	3, 849	2, 789	1, 729	836	323	99
Slight	2, 856	5, 855	9, 443	7, 774	4, 880	2, 468	1, 321	532	184	42
Moderate	8, 656	16, 628	23, 325	15, 188	6, 969	2, 862	1, 158	374	113	31
Deep	2, 426	4, 314	5, 438	3, 197	1, 343	501	206	69	25	8
	Number of Person-Years									
None	3, 727	7, 861	14, 905	16, 923	14, 553	10, 505	6, 447	3, 023	1, 165	324
Slight	10, 801	22, 293	35, 874	29, 483	18, 438	9, 238	4, 876	1, 912	636	133
Moderate	32, 821	63, 193	88, 652	57, 610	26, 350	10, 746	4, 267	1, 339	386	95
Deep	9, 153	16, 378	20, 555	12, 097	5, 032	1, 861	764	245	88	20
	Number of Deaths									
None	1	19	31	69	96	95	102	92	45	32
Slight	24	42	107	128	129	105	98	58	32	16
Moderate	44	122	274	279	190	126	90	49	21	10
Deep	14	44	96	74	47	26	14	9	6	4
	Death Rates per 100,000 Person-Years									
None	*	242	208	408	660	904	1, 582	3, 043	3, 863	9, 877
Slight	222	188	298	434	700	1, 137	2, 010	3, 033	5, 031	12, 030
Moderate	134	193	309	484	721	1, 173	2, 109	3, 659	5, 440	*
Deep	153	269	467	612	934	1, 397	1, 832	*	*	*

See footnotes at end of Appendix tables.

APPENDIX TABLE 5a.—Number of men, number of person-years, number of deaths, and death rates for persons with history of only cigarette smoking, who were currently smoking cigarettes at time of enrollment, by age began cigarette smoking and age at start of study

Age began cigarette smoking	Age									
	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84
	Number of Men at Start									
30+	78	231	1, 062	1, 288	1, 118	873	656	449	188	65
25–29	214	560	1, 635	1, 623	1, 266	651	537	214	61	10
20–24	1, 842	2, 834	9, 080	8, 726	5, 407	3, 440	1, 533	572	191	48
15–19	5, 062	7, 999	22, 188	18, 811	12, 073	6, 359	3, 037	1, 159	360	90
<15	972	1, 792	4, 627	4, 227	2, 730	1, 736	992	466	133	50
	Number of Person-Years									
30+	297	873	4, 033	4, 899	4, 197	3, 229	2, 390	1, 574	640	206
25–29	808	2, 126	6, 193	6, 131	4, 715	2, 393	1, 934	758	199	19
20–24	6, 988	10, 728	34, 386	32, 805	20, 162	12, 606	5, 492	1, 976	633	148
15–19	19, 115	30, 194	83, 581	70, 580	44, 632	23, 058	10, 651	3, 937	1, 132	259
<15	3, 668	6, 724	17, 359	15, 715	10, 042	6, 271	3, 473	1, 536	412	142
	Number of Deaths									
30+	1	3	20	31	49	69	74	81	48	24
25–29	0	5	33	57	85	59	66	36	20	8
20–24	14	35	221	356	312	348	217	120	53	21
15–19	62	150	672	851	908	729	525	280	117	46
<15	10	36	153	245	216	214	192	114	47	22
	Death Rates per 100,000 Person-Years									
30+	*	*	496	633	1, 168	2, 137	3, 096	5, 146	7, 500	11, 650
25–29	*	*	533	930	1, 803	2, 466	3, 413	4, 749	10, 050	*
20–24	200	326	643	1, 085	1, 547	2, 761	3, 951	6, 073	8, 373	14, 189
15–19	324	497	804	1, 206	2, 034	3, 162	4, 929	7, 112	10, 336	17, 761
<15	*	535	881	1, 559	2, 151	3, 413	5, 528	7, 422	11, 408	15, 493

See footnotes at end of Appendix tables.

APPENDIX TABLE 5b.—Number of women, number of person-years, number of deaths, and death rates for women, who were currently smoking cigarettes at time of enrollment, by age began cigarette smoking and age at start of study

Age began cigarette smoking	Age									
	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84
	Number of Women at Start									
30+	940	2, 804	6, 319	7, 853	7, 548	5, 243	3, 215	1, 389	520	142
25–29	1, 175	2, 646	4, 681	5, 248	3, 609	1, 372	458	123	35	4
20–24	4, 379	7, 479	12, 516	9, 178	3, 445	1, 032	303	99	30	6
15–19	7, 670	14, 292	16, 886	7, 312	1, 873	588	214	87	15	10
<15	555	1, 237	1, 079	431	130	64	33	12	7	5
	Number of Person-Years									
30+	3, 550	10, 687	24, 032	29, 788	28, 515	19, 721	11, 960	5, 016	1, 851	471
25–29	4, 445	10, 066	17, 793	19, 940	13, 661	5, 153	1, 706	443	124	12
20–24	16, 603	28, 421	47, 570	34, 811	13, 017	3, 838	1, 096	348	107	15
15–19	29, 048	54, 306	64, 047	27, 732	7, 045	2, 191	776	305	49	26
<15	2, 094	4, 685	4, 099	1, 616	490	237	116	44	18	16
	Number of Deaths									
30+	5	12	63	121	191	209	203	152	80	40
25–29	4	14	56	94	100	51	27	17	4	2
20–24	29	73	136	177	93	52	31	14	4	3
15–19	40	115	230	132	64	24	19	14	6	6
<15	1	12	14	12	4	5	5	1	3	3
	Death Rates per 100,000 Person-Years									
30+	*	112	262	406	670	1, 060	1, 697	3, 030	4, 322	8, 493
25–29	*	139	315	471	732	990	1, 583	3, 837	*	*
20–24	175	257	286	508	714	1, 355	2, 828	*	*	*
15–19	138	212	359	476	908	1, 095	2, 448	*	*	*
<15	*	*	342	*	*	*	*	*	*	*

See footnotes at end of Appendix tables.

APPENDIX TABLE 6.—Number of person-years and number of deaths for subjects with a history of only cigarette smoking, who were currently smoking cigarettes at time of enrollment, by number of cigarettes smoked per day and age began smoking, and by number of cigarettes smoked per day and degree of inhalation, by age at start of study

Current number of cigarettes per day	Men			Women			Men		Women	
	Age began smoking			Age began smoking			Degree of inhalation		Degree of inhalation	
	25+	15–24	<15	25+	15–24	<15	None-slight	Moderate-deep	None-slight	Moderate-deep
	Number of Person-Years—Subjects Aged 45–49 at Start of Study									
1–9	1, 564*	6, 990	743*	14, 334	21, 238	552*	4, 068	5, 229	21, 605	14, 519
10–19	2, 163	18, 573	2, 071	13, 212	36, 406	1, 084*	4, 599	18, 208	14, 928	35, 774
20–39	5, 274	74, 823	10, 926	13, 275	49, 503	2, 114*	9, 958	81, 065	11, 841	53, 051
40+	1, 130*	16, 792	3, 488	817*	4, 143	345*	2, 110	19, 300	976*	4, 329
	Number of Deaths—Subjects Aged 45–49 at Start of Study									
1–9	11	47	1	37	42	2	24	35	47	34
10–19	11	128	22	37	108	1	30	131	41	105
20–39	27	558	103	37	193	8	79	609	40	198
40+	4	155	26	8	22	2	16	169	4	28
	Number of Person-Years—Subjects Aged 50–54 at Start of Study									
1–9	1, 754	6, 712	713*	15, 613	12, 634	281*	4, 224	4, 955	19, 534	8, 992
10–19	2, 298	16, 999	1, 973	15, 790	19, 992	393*	4, 917	16, 353	12, 984	23, 192
20–39	5, 564	64, 129	9, 925	17, 020	27, 130	764*	10, 553	69, 065	11, 540	33, 374
40+	1, 305	14, 616	2, 932	1, 104*	2, 557*	175*	2, 570	16, 283	864*	2, 971*

See footnotes at end of Appendix tables.

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APPENDIX TABLE 6.—Number of person-years and number of deaths for subjects with a history of only cigarette smoking, who were currently smoking cigarettes at time of enrollment, by number of cigarettes smoked per day and age began smoking, and by number of cigarettes smoked per day and degree of inhalation, by age at start of study—Continued

Current number of cigarettes per day	Men			Women			Men		Women	
	Age began smoking			Age began smoking			Degree of inhalation		Degree of inhalation	
	25+	15–24	<15	25+	15–24	<15	None-slight	Moderate-deep	None-slight	Moderate-deep
	Number of Deaths—Subjects Aged 50–54 at Start of Study									
1–9	5	64	9	50	43	1	33	45	58	36
10–19	21	186	34	68	90	3	47	194	65	96
20–39	50	757	144	91	159	6	116	835	60	196
40+	11	189	55	6	15	2	29	226	3	20
	Number of Person-Years—Subjects Aged 55–59 at Start of Study									
1–9	1, 534	5, 058	561*	12, 927	4, 444	118*	3, 673	3, 480	13, 593	3, 896
10–19	2, 025	12, 532	1, 372	13, 266	6, 292	132*	4, 486	11, 443	9, 299	10, 391
20–39	4, 396	38, 879	6, 360	14, 665	8, 394	207*	8, 815	40, 820	8, 014	15, 252
40+	841	7, 593	1, 611	1, 044*	825*	31*	1, 694	8, 351	709*	1, 191*
	Number of Deaths—Subjects Aged 55–59 at Start of Study									
1–9	13	69	10	78	31	0	43	49	84	25
10–19	32	219	32	91	53	2	74	209	63	83
20–39	69	742	130	110	67	2	180	761	64	115
40+	18	173	44	11	5	0	32	203	5	11
	Number of Person-Years—Subjects Aged 60–64 at Start of Study									
1–9	1, 116	3, 770	451	8, 336	1, 622	59*	2, 930	2, 407	8, 335	1, 682
10–19	1, 411	8, 163	1, 224	7, 660	1, 898	49*	3, 642	7, 156	5, 288	4, 319

20–39	2, 539	20, 078	3, 729	8, 161	2, 264	103*	5, 851	20, 495	4, 693	5, 835
40+	438	3, 075	796	530*	186*	20*	1, 042	3, 267	296*	440*
	Number of Deaths—Subjects Aged 60–64 at Start of Study									
1–9	29	83	22	63	18	0	72	62	64	17
10–19	36	239	35	88	20	1	106	204	70	39
20–39	51	635	125	102	37	4	165	646	54	89
40+	9	97	28	6	1	0	27	107	4	3
	Number of Person-Years—Subjects Aged 65–69 at Start of Study									
1–9	1, 088	2, 009	357	4, 966	620*	55*	2, 045	1, 409	4, 844	797
10–19	1, 264	4, 348	810	4, 236	549*	27*	2, 400	4, 022	2, 997	1, 815
20–39	1, 688	8, 515	1, 902	4, 038	641*	28*	3, 464	8, 641	2, 621	2, 086
40+	185*	978	341	230*	57*	7*	425	1, 079	156*	138*
	Number of Deaths—Subjects Aged 65–69 at Start of Study									
1–9	25	89	23	77	13	2	76	61	76	16
10–19	46	197	56	63	17	3	105	194	54	29
20–39	62	393	96	78	17	0	141	410	47	48
40+	5	52	14	8	3	0	22	49	6	5
	Number of Person-Years—Subjects Aged 70–74 at Start of Study									
1–9	643	1, 059	225	2, 284	288*	8*	1, 271	656	2, 261	319*
10–19	749	1, 799	446	1, 634	210*	22*	1, 276	1, 718	1, 292	574
20–39	801	2, 703	713	1, 411	141*	14*	1, 444	2, 773	1, 009	557
40+	80*	255	111*	70*	8*	0*	136*	310	42*	36*
	Number of Deaths—Subjects Aged 70–74 at Start of Study									
1–9	29	71	16	62	10	0	75	41	62	10
10–19	39	112	30	49	7	0	58	123	35	21
20–39	47	182	58	56	11	1	88	199	43	25
40+	1	23	7	0	0	0	10	21	0	0

See footnotes at end of Appendix tables.

Appendix table 7.—Number of men, number of person-years, number of deaths, and death rates for men with a history of cigarette and other smoking, who were currently smoking cigarettes at time of enrollment, by current number of cigarettes smoked per day and age at start of study

Current number of cigarettes per day	Age									
	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84
	Number of Men at Start									
1–9	346	600	1, 887	2, 080	1, 888	1, 476	1, 114	709	302	112
10–19	439	884	2, 669	2, 800	2, 297	1, 870	1, 258	661	257	74
20–39	1, 232	2, 308	6, 919	6, 676	4, 817	3, 040	1, 863	784	219	47
40+	243	440	1, 328	1, 234	740	398	198	54	16	10
	Number of Person-Years									
1–9	1, 321	2, 272	7, 168	7, 865	7, 061	5, 433	4, 014	2, 498	1, 007	342
10–19	1, 661	3, 350	10, 077	10, 571	8, 618	6, 895	4, 551	2, 270	868	237
20–39	4, 669	8, 724	26, 196	25, 123	17, 900	11, 191	6, 719	2, 711	733	134
40+	920	1, 647	4, 993	4, 600	2, 732	1, 444	725	183	55	24
	Number of Deaths									
1–9	3	5	25	63	97	133	145	123	81	49
10–19	5	12	65	101	116	160	166	151	57	28
20–39	13	44	158	280	333	255	254	172	50	22
40+	6	12	46	59	64	53	22	11	4	6
	Death Rates per 100,000 Person-Years									
1–9	*	*	349	801	1, 374	2, 448	3, 612	4, 924	8, 044	14, 327
10–19	*	358	645	955	1, 346	2, 321	3, 648	6, 652	6, 567	11, 814
20–39	278	504	603	1, 115	1, 860	2, 279	3, 780	6, 345	6, 821	16, 418
40+	*	*	921	1, 283	2, 343	3, 670	3, 034	*	*	*

See footnotes at end of Appendix tables.

APPENDIX TABLE 8.—Number of men, number of person-years, number of deaths, and death rates for men with history of cigarette and other smoking, who were currently smoking cigarettes at time of enrollment, by degree of inhalation and age at start of study

Degree of inhalation	Age									
	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84
	Number of Men at Start									
None	207	357	1, 196	1, 563	1, 629	1, 302	963	560	231	79
Slight	314	564	1, 732	1, 938	1, 695	1, 388	1, 007	571	227	72
Moderate	1, 072	2, 088	6, 662	6, 411	4, 583	3, 046	1, 895	823	260	69
Deep	669	1, 219	3, 222	2, 890	1, 847	1, 030	566	237	71	24
	Number of Person-Years									
None	788	1, 354	4, 545	5, 916	6, 102	4, 796	3, 481	1, 963	806	235
Slight	1. 194	2, 142	6, 556	7, 317	6, 328	5, 097	3, 663	2, 005	745	227
Moderate	4, 066	7, 884	25, 199	24, 161	17, 071	11, 249	6. 826	2, 838	865	216
Deep	2, 532	4, 599	12, 174	10, 807	6, 848	3, 745	2, 031	802	229	65
	Number of Deaths									
None	2	3	16	47	75	113	116	108	44	34
Slight	8	7	29	67	106	129	123	107	57	31
Moderate	7	39	161	249	309	252	262	181	68	23
Deep	10	23	86	146	120	108	84	57	22	16
	Death Rates per 100,000 Person-Years									
None	*	*	352	794	1, 229	2, 356	3, 332	5, 502	5, 459	14, 468
Slight	670	*	442	916	1, 675	2, 531	3, 358	5, 337	7, 651	13, 656
Moderate	172	495	639	1, 031	1, 810	2, 240	3, 838	6. 378	7, 861	10, 648
Deep	*	500	706	1, 351	1, 752	2, 884	4, 136	7, 107	9, 607	*

See footnotes at end of Appendix tables.

APPENDIX TABLE 9.—Number of men, number of person-years, number of deaths, and death rates for men with history of cigarette and other smoking, who were currently smoking cigarettes at time of enrollment, by age began smoking and age at start of study

Age began cigarette smoking	Age									
	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84
	Number of Men at Start									
30+	40	111	483	597	597	550	588	449	204	79
25–29	73	190	608	667	529	361	342	179	44	10
20–24	530	911	2, 913	2, 979	2, 301	1, 615	937	385	125	48
15–19	1, 271	2, 361	6, 912	6, 571	4, 833	3, 078	1, 773	781	252	63
<15	306	561	1, 616	1, 655	1, 233	925	616	310	98	24
	Number of Person-Years									
30+	153	419	1, 840	2, 258	2, 222	2, 019	2, 140	1, 576	699	250
25–29	279	722	2, 299	2, 529	1, 992	1, 340	1, 235	633	151	31
20–24	2, 016	3, 459	11, 034	11, 215	8, 638	5, 931	3, 379	1, 349	422	135
15–19	4, 819	8, 909	26, 166	24, 737	17, 958	11, 321	6, 380	2, 678	847	191
<15	1, 150	2, 118	6, 081	6, 192	4, 557	3, 395	2, 231	1, 069	298	81
	Number of Deaths									
30+	0	1	6	18	39	54	72	85	47	28
25–29	1	2	9	16	25	31	43	30	8	3
20–24	6	13	52	115	120	138	123	75	29	23
15–19	13	40	161	260	326	269	242	176	61	31
<15	7	13	52	85	93	94	84	72	33	7

	Death Rates per 100,000 Person-Years									
30+	*	*	326	797	1, 755	2, 675	3, 364	5, 398	6, 724	11, 200
25–29	*	*	391	633	1, 255	2, 313	3, 482	4, 739	5, 298	*
20–24	*	376	471	1, 025	1, 389	2, 327	3, 640	5, 560	6, 872	17, 037
15–19	270	449	615	1, 051	1, 815	2, 376	3, 793	6, 572	7, 202	16, 230
<15	*	*	855	1, 373	2, 041	2, 769	3, 765	6, 735	11, 074	*

See footnotes at end of Appendix tables.

APPENDIX TABLE 10.—Number of men, number of person-years, number of deaths, and death rates for men with history of cigarette smoking only, who had stopped smoking at start of study, by former amount of cigarettes smoked per day and years since last smoked, by age at start of study

Ex-cigarette smokers years since last cigarette smoking	Age									
	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84
	HAD SMOKED 1–19 CIGARETTES A DAY									
	Number of Men at Start of Study									
Less than 1 year	64	92	289	297	211	142	96	68	26	4
1–4 years	142	226	699	628	508	413	295	142	76	9
5–9 years	129	173	633	633	492	378	267	139	59	15
10+ years	150	350	1, 315	1, 353	1, 186	950	720	407	178	73
	Number of Person-Years									
Less than 1 year	244	346	1, 102	1, 113	789	522	345	231	81	10
1–4 years	539	853	2, 647	2, 389	1, 889	1, 513	1, 057	472	231	29
5–9 years	488	663	2, 392	2, 373	1, 823	1, 403	987	479	197	52
10+ years	567	1, 328	5, 014	5, 154	4, 485	3, 576	2, 623	1, 412	598	220
	Number of Deaths									
Less than 1 year	0	2	3	11	11	15	13	14	9	2
1–4 years	2	3	12	10	26	38	36	34	29	4
5–9 years	0	1	14	22	28	26	24	28	17	6
10+ years	4	2	15	25	38	45	74	73	46	25
	Death Rates per 100,000 Person-Years									
Less than 1 year	*	*	*	988	1, 394	2, 874	3, 768	6, 061	*	*
1–4 years	*	*	453	419	1, 376	2, 512	3, 406	7, 203	12, 554	*

5–9 years	*	*	585	927	1, 536	1, 853	2, 432	5, 846	8, 629	*
10+ years	*	*	299	485	847	1, 258	2, 821	5, 170	7, 692	11, 364
	HAD SMOKED 20 OR MORE CIGARETTES A DAY									
	Number of Men at Start of Study									
Less than 1 year	226	341	1, 085	932	686	417	209	77	20	4
1–4 years	355	639	2, 029	2, 114	1, 593	1, 129	599	229	87	21
5–9 years	342	645	2, 181	2, 240	1, 728	1, 167	668	290	77	18
10+ years	228	522	2, 214	2, 795	2, 430	1, 789	1, 128	498	183	40
	Number of Person-Years									
Less than 1 year	856	1, 281	4, 050	3, 498	2, 493	1, 498	697	266	63	11
1–4 years	1, 351	2, 397	7, 656	7, 927	5, 883	4, 088	2, 098	764	263	62
5–9 years	1, 287	2, 449	8, 289	8, 454	6, 463	4, 295	2, 385	1, 006	253	46
10+ years	867	1, 993	8, 429	10, 598	9, 130	6, 573	4, 059	1, 708	598	112
	Number of Deaths									
Less than 1 year	3	6	46	34	67	50	47	15	6	2
1–4 years	3	13	50	90	120	139	96	54	29	9
5–9 years	3	5	29	76	95	105	85	55	20	11
10+ years	3	4	28	58	99	146	139	104	48	17
	Death Rates per 100,000 Person-Years									
Less than 1 year	*	*	1, 136	972	2, 688	3, 338	6, 743	5, 639	*	*
1–4 years	*	*	653	1, 135	2, 040	3, 400	4, 576	7, 068	11, 027	*
5–9 years	*	*	350	899	1, 470	2, 445	3, 564	5, 467	7, 905	*
10+ years	*	*	332	547	1, 084	2, 221	3, 424	6, 089	8, 027	15, 179

See footnotes at end of Appendix tables.

APPENDIX TABLE 11.—Number of men, number of person-years, number of deaths, and death rates for men with history of only pipe smoking, for ex-pipe smokers, and for current pipe smokers, by number of pipefuls smoked per day and degree of inhalation, by age at start of study

History of pipe only	Age 35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84
	Number of Men at Start									
Pipe smokers (total)	350	684	2, 013	2, 153	1, 873	1, 833	1, 818	1, 429	848	435
Ex-pipe smokers	88	187	539	555	493	495	558	449	278	134
Current pipe smokers (total)	262	497	1, 474	1, 598	1, 380	1, 338	1, 260	980	570	301
1–9 a day	157	297	838	840	772	713	706	580	377	197
10+ a day	95	183	569	663	520	509	430	301	157	77
No inhalation	163	322	956	1, 105	979	933	882	707	400	199
Some inhalation	91	168	479	455	345	335	299	201	134	71
	Number of Person-Years									
Pipe smokers (total)	1, 326	2, 604	7, 683	8, 188	7, 073	6, 814	6, 636	5, 101	2, 936	1, 397
Ex-pipe smokers	331	711	2, 063	2, 099	1, 852	1, 818	1, 987	1, 592	935	442
Current pipe smokers (total)	995	1, 892	5, 620	6, 090	5, 221	4, 997	4, 649	3, 509	2, 001	954
1–9 a day	596	1, 131	3, 191	3, 197	2, 916	2, 661	2, 610	2, 071	1, 304	629
10+ a day	360	695	2, 175	2, 534	1, 975	1, 902	1, 584	1, 080	569	247
No inhalation	621	1, 227	3, 643	4, 217	3, 726	3, 484	3, 268	2, 548	1, 407	637
Some inhalation	344	639	1, 826	1, 730	1, 286	1, 245	1, 089	699	477	223
	Number of Deaths									
Pipe smokers (total)	4	3	17	46	73	131	195	199	175	159
Ex-pipe smokers	3	1	1	21	20	42	78	67	67	42
Current pipe smokers (total)	1	2	16	25	53	89	117	132	108	117
1–9 a day	1	1	10	16	27	50	61	76	80	77
10+ a day	0	1	6	8	19	29	43	42	22	26

No inhalation	0	2	13	14	28	66	71	86	72	78
Some inhalation	1	0	3	9	22	20	36	34	25	26
	Death Rates per 100,000 Person-Years									
Pipe smokers (total)	*	*	221	562	1, 032	1, 923	2, 939	3, 901	5, 960	11, 382
Ex-pipe smokers	*	*	48	1, 000	1, 080	2, 310	3, 926	4, 209	7, 166	9, 502
Current pipe smokers (total)	*	*	285	411	1, 015	1, 781	2, 517	3, 762	5, 397	12, 264
1–9 a day	*	*	313	500	926	1, 879	2, 337	3, 670	6, 135	12, 242
10+ a day	*	*	276	316	962	1, 525	2, 715	3, 889	3, 866	10, 526
No inhalation	*	*	357	332	751	1, 894	2, 173	3, 375	5, 117	12, 245
Some inhalation	*	*	164	520	1, 711	1, 606	3, 306	4, 864	5, 241	11, 659

See footnotes at end of Appendix tables.

Appendix table 12.—Number of men, number of person-years, number of deaths, and death rates for men with history of only cigar smoking, for ex-cigar smokers, and for current cigar smokers, by number of cigars smoked per day and degree of inhalation, by age at start of study

History of cigar only	Age									
	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84
	Number of Men at Start									
Cigar smokers (total)	509	877	2, 856	3, 595	3, 680	3, 488	2, 841	1, 831	1, 049	435
Ex-cigar smokers	60	131	459	750	902	1, 039	1, 011	703	452	190
Current cigar smokers (total)	449	746	2, 397	2, 845	2, 778	2, 449	1, 830	1, 128	597	245
1–4 a day	325	527	1, 648	1, 895	1, 819	1, 668	1, 333	842	465	189
5+ a day	119	210	727	921	919	745	473	269	122	51
No inhalation	308	538	1, 774	2, 176	2, 198	2, 008	1, 515	919	465	167
Some inhalation	126	189	572	603	506	362	230	156	88	55
	Number of Person-Years									
Cigar smokers (total)	1, 914	3, 313	10, 841	13, 633	13, 832	12, 949	10, 364	6, 536	3, 555	1, 375
Ex-cigar smokers	224	493	1, 737	2, 835	3, 364	3, 823	3, 620	2, 524	1, 511	589
Current cigar smokers (total)	1, 690	2, 820	9, 104	10, 799	10, 468	9, 125	6, 743	4, 012	2, 044	785
1–4 a day	1, 219	1, 998	6, 277	7, 199	6, 888	6, 218	4, 912	2, 983	1, 602	606
5+ a day	451	787	2, 747	3, 490	3, 431	2, 778	1, 742	970	417	163
No inhalation	1, 164	2, 036	6, 761	8, 289	8, 286	7, 478	5, 600	3, 298	1, 593	548
Some inhalation	474	713	2, 154	2, 265	1, 903	1, 347	834	527	297	158
	Number of Deaths									
Cigar smokers (total)	7	11	37	83	151	261	290	267	257	155
Ex-cigar smokers	1	5	11	25	53	89	126	101	121	75
Current cigar smokers (total)	6	6	26	58	98	172	164	166	136	80
1–4 a day	5	2	14	37	60	118	118	132	104	64
5+ a day	1	4	12	21	36	48	45	32	27	14

No inhalation	2	4	15	38	74	142	126	120	106	52
Some inhalation	2	1	10	17	21	24	28	37	21	22
	Death Rates per 100,000 Person-Years									
Cigar smokers (total)	*	332	341	609	1,092	2,016	2,798	4,085	7,229	11,273
Ex-cigar smokers	*	*	*	882	1,576	2,328	3,481	4,002	8,008	12,733
Current cigar smokers (total)	*	213	286	537	936	1,885	2,432	4,138	6,654	10,191
1–4 a day	*	*	223	514	871	1,898	2,402	4,425	6,492	10,561
5+ a day	*	*	437	602	1,049	1,728	2,583	3,299	6,475	8,589
No inhalation	*	*	222	458	893	1,899	2,250	3,639	6,654	9,489
Some inhalation	*	*	464	751	1,104	1,782	3,357	7,021	7,071	13,924

See footnotes at end of Appendix tables.

Appendix table 13.—Number of deaths and percent of deaths, by underlying cause of death

Underlying cause of death	International List Nos.	MEN		WOMEN	
		Number	Percent	Number	Percent
Cancer (total)	—	4, 889	18. 9	4, 884	29. 9
Lung (excl. trachea, pleura)	(162)	1, 159	4. 5	210	1. 3
Buccal cavity, pharynx	140–148	118	0. 5	43	0. 3
Larynx	161	59	0. 2	2	<0. 1
Esophagus	150	60	0. 2	17	0. 1
Bladder and other urinary	181	169	0. 7	68	0. 4
Kidney	180	126	0. 5	69	0. 4
Prostate	177	450	1. 7	—	—
Pancreas	157	335	1. 3	234	1. 4
Liver, biliary passages	155	126	0. 5	152	0. 9
Stomach	150	343	1. 3	219	1. 3
Colon, rectum	153, 154	744	2. 9	750	4. 6
Leukemia	204	266	1. 0	189	1. 2
Lymphoma, Hodgkin's disease	200–203, 205	294	1. 1	265	1. 6
Breast	170	8	<0. 1	1, 318	8. 1
Uterus	171–174	—	—	401	2. 5
Ovary, Fallopian tubes	175	—	—	396	2. 4
Other specified sites		415	1. 6	331	2. 0
Cancer—site not specified	199	217	0. 8	220	1. 3
Heart and circulatory (total)	—	16, 434	63. 5	8, 727	53. 5
Coronary heart disease	420	11, 556	44. 6	4, 654	28. 5
Rheumatic heart disease	400–402, 410–416	308	1. 2	311	1. 9
Hypertensive heart disease	440–443	577	2. 2	617	3. 8
Other heart disease	421, 422, 430–434	841	3. 2	603	3. 7
Aortic aneurysm (non-syphilitic)	451	355	1. 4	86	0. 5
Cerebral vascular lesions	330–334	2, 227	8. 6	2, 010	12. 3
Other circulatory diseases	444–447, 450, 452–468	570	2. 3	446	2. 8

Appendix table 13.—Number of deaths and percent of deaths, by underlying cause of deaths—Continued

Underlying cause of death	International List Nos.	MEN		WOMEN	
		Number	Percent	Number	Percent
Other diseases (total)	—	3, 332	12. 8	2, 089	12. 7
Emphysema	(527.1)	425	1. 6	48	0. 3
Pneumonia, influenza	480, 481, (490–493)	391	1. 5	223	1. 4
Other pulmonary diseases	001–002, 241, (490–493), 500–502, 520–526, 527. 0 527. 2	289	1. 1	136	0. 8
Gastric ulcer	541	114	0. 4	36	0. 2
Duodenal ulcer	540, 542	141	0. 5	46	0. 3
Cirrhosis of liver	581	279	1. 1	138	0. 8
Nephritis and other kidney diseases	590–594, 600–603	272	1. 1	201	1. 2
Diabetes	260	283	1. 1	359	2. 2
Other specified diseases	All other	1, 029	4. 0	848	5. 2
Ill-defined diseases	780–795	109	0. 4	54	0. 3
Violence, accidents, suicide	E800–E965, E970–E999	1, 240	4. 8	633	3. 9
Total death certificates received	—	25, 895	100. 0	16, 333	100. 0
Death certificates not yet received	—	553	—	440	—
Grand total	—	26, 448	—	16, 773	—

APPENDIX TABLE 14.—Coronary heart disease. Number of deaths by type of smoking (lifetime history) and by age at start of study

Type of smoking (lifetime history)	Age									
	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84
	CHD—Number of Deaths									
Men										
Never smoked regularly	0*	19	60	154	229	338	393	457	337	220
Pipe only	2*	1*	6	17	33	61	89	76	72	61
Pipe and cigar	0*	2*	13	21	37	62	88	89	90	57
Cigar only	3*	3*	14	30	72	133	120	101	111	58
Cigarette and other	14*	37	197	379	457	486	481	380	183	82
Cigarette only	27	121	604	955	1, 016	931	718	463	220	76
Total	46	183	894	1, 556	1, 844	2, 011	1, 889	1, 566	1, 013	554
Women										
Never smoked regularly	5*	21	51	118	237	451	672	850	755	572
Cigarette	5*	31	77	131	159	156	160	114	50	39
Total	10	52	128	249	396	607	832	964	805	611

See footnotes at end of Appendix tables.

APPENDIX TABLE 15.—Coronary heart disease. Number of deaths of current cigarette smokers, with history of only cigarette smoking, by current number of cigarettes smoked per day, degree of inhalation, and age began smoking, by age at start of study

Number of cigarettes per day, degree of inhalation, and age began smoking	Age									
	35–39	40–44	45–49	50–54	55–59	60–64	65–59	70–74	75–79	80–84
	Coronary Heart Disease—Number of Deaths (Men)									
Current number of cigarettes per day:										
1–9	3*	3*	27	43	56	59	71	38	31	14
10–19	3*	9	82	130	143	146	133	88	42	12
20–39	11	74	322	493	465	383	236	128	43	11
40+	8*	21	91	116	118	53	31	6*	5*	0*
Degree of inhalation:										
None-slight	3*	13	77	107	164	179	166	87	65	22
Moderate-deep	25	97	457	703	686	591	424	272	169	73
Age began cigarette smoking:										
25 or older	1*	3*	27	50	67	65	61	47	25	7
15–24	20	87	420	602	602	457	319	164	74	18
<15	3*	14	64	107	90	91	67	39	18	8*
	Coronary Heart Disease—Number of Deaths (Women)									
Current number of cigarettes per day:										
1–9	2*	2*	7	13	24	34	32	31	12	13*
10–19	1*	4*	15	39	44	34	39	24	16	6*
20–39	2*	19*	45	50	55	51	43	30	7*	4*
40+	0*	2*	3*	6*	9*	4*	4*	0*	0*	0*
Degree of inhalation:										
None-slight	2*	9*	19	39	72	64	76	57	23	21
Moderate-deep	3*	18	50	68	60	59	41	28	12*	2*
Age began cigarette smoking:										
25 or older	0*	3*	20	43	83	100	90	70	29	17
15–24	5*	22	47	59	44	20	16*	12*	3*	3*
<15	0*	2*	1*	4*	2*	1*	2*	0*	0*	1*

See footnotes at end of Appendix tables.

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APPENDIX TABLE 16.—Coronary heart disease (men). Number of deaths and death rates for ex-cigarette smokers with history of cigarette smoking only, by former number of cigarettes smoked per day, and years since last cigarette smoking, by age at start of study

Ex-cigarette smokers (years since last cigarette smoking)	Age									
	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84
	HAD SMOKED 1–19 CIGARETTES A DAY									
	Number of Deaths (Men)									
Less than 1 year	0	1	1	6	8	9	4	9	5	0
1–4 years	0	1	5	5	12	21	13	14	10	2
5–9 years	0	0	6	9	18	10	11	10	7	1
10+ years	1	0	8	10	18	24	32	34	15	10
Current cigarette smokers	6	12	109	173	199	205	204	126	73	26
	Death Rates per 100,000 Person-Years									
Less than 1 year	*	*	*	539†	1, 014†	1, 724†	1, 159†	*	*	*
1–4 years	*	*	*	209	635	1, 388	1, 230	*	*	*
5–9 years	*	*	*	379	987	713	1, 114	2, 088	*	*
10+ years	*	*	160	194	401	671	1, 220	2, 408	2, 508	*
Current cigarette smokers	*	103	325	539	814	1, 189	1, 909	2, 306	3, 728	4, 693

	HAD SMOKED 20 OR MORE CIGARETTES A DAY									
	Number of Deaths (Men)									
Less than 1 year	0	1	13	16	22	22	17	5	1	1
1–4 years	0	7	20	48	51	67	29	24	12	8
5–9 years	1	3	13	36	45	40	31	25	5	2
10+ years	0	0	13	29	42	72	63	48	18	6
Current cigarette smokers	19	95	413	609	583	436	267	134	48	11
	Death Rates per 100,000 Person-Years									
Less than 1 year	*	*	*	457	882	1, 469	2, 439 †	*	*	*
1–4 years	*	*	261	606	867	1, 639	1, 382	3, 141	*	*
5–9 years	*	*	157	426	696	931	1, 300	2, 485	*	*
10+ years	*	*	154	274	460	1, 095	1, 552	2, 810	3, 010	*
Current cigarette smokers	78	235	356	599	938	1, 357	1, 840	2, 666	3, 496	3, 514

See footnotes at end of Appendix tables.

Appendix table 17.—Cerebral vascular lesions. Number of deaths, by type of smoking (lifetime history) and age at start of study

Type of smoking (lifetime history)	Age									
	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84
	CVL—Number of Deaths									
Men										
Never smoked regularly	1‡	5‡	8	32	36	61	97	115	136	105
Pipe, cigar	0‡	1‡	5	10	22	38	65	93	103	81
Cigarette and other	1‡	5†	13	31	65	77	88	80	45	26
Cigarette only	10†	10	56	99	94	155	148	125	54	31
Total	12	21	82	172	217	331	398	413	338	243
Women										
Never smoked regularly	5†	13	39	52	90	151	233	299	362	371
Cigarette	8†	23	52	69	54	48	54	38	29	20
Total	13	36	91	121	144	199	287	337	391	391

See footnotes at end of Appendix tables.

Appendix table 18.—Cerebral vascular lesions. Number of deaths of current cigarette smokers with history of only cigarette smoking, by current number of cigarettes smoked per day, degree of inhalation, and age began smoking, by age at start of study

Number of cigarettes per day, degree of inhalation, and age began smoking	Age									
	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84
	CVL—Number of Deaths (Men)									
Current number of cigarettes per day:										
1–9	1‡	1‡	4‡	4†	7†	11†	14	15	5†	5†
10–19	1‡	0‡	4†	10	11	25	28	20	7†	5†
20–39	6‡	7†	35	52	49	72	43	34	15	6†
40+	1‡	0‡	9†	20†	6†	10†	3†	6‡	2‡	2‡
Degree of inhalation:										
None-slight	1‡	2‡	5†	23	12	31	32	34	15	9
Moderate-deep	7†	6†	47	62	61	90	55	42	13	10
Age began cigarette smoking:										
25 or older	0‡	0‡	3‡	5†	5	16	10	18	9	7
15–24	8†	7†	39	67	56	83	58	44	12	8
<15	0‡	1‡	8‡	12†	10	10	12	11	4	3
	CVL—Number of Deaths (Women)									
Current number of cigarettes per day:										
1–9	2‡	3‡	4†	9†	12†	7†	11	8†	14†	9†
10–19	4‡	6†	16	22	14†	17†	16†	5†	4†	2‡
20–39	2‡	9†	23	28	15	16†	12†	10†	3†	2‡
40+	0‡	1‡	5‡	5‡	0‡	0‡	1‡	0‡	0‡	0‡
Degree of inhalation:										
None-slight	3‡	7‡	7	24	17	25	26	16	14	7
Moderate-deep	5‡	12	41	40	24	15	14†	7†	5‡	6‡
Age began cigarette smoking:										
25 or older	3‡	0‡	8†	25	26	28	31	18	17	9
15–24	5†	18	34	37	12	8†	6‡	4‡	0‡	2‡
<15	0‡	1‡	4‡	0‡	0‡	1‡	1‡	0‡	1‡	0‡

See footnotes at end of Appendix tables.

APPENDIX TABLE 19.—Women aged 65–79. Number of deaths and age-standardized death rates, by underlying cause of death. Women aged 65–79 who never smoked regularly compared with women with history of cigarette smoking and with "heavier" cigarette smokers

Underlying cause of death	Never smoked regularly		History of cigarette smoking		"Heavier" cigarette smokers	
	Number of deaths	Death rate	Number of deaths	Death rate	Number of deaths	Death rate
Cancer (total)	1, 443	518	181	572	46	596
Lung (excl. trachea, pleura)	48	17	10	30	7	77
Buccal cavity, pharynx, larynx, and esophagus	19	7	3	8	0	—
Pancreas	89	32	15	45	2	18
Colon; rectum	281	101	39	122	5	59
Breast	255	92	30	97	8	103
Uterus	109	39	15	49	5	79
Ovary	94	34	11	39	3	51
Leukemia, lymphoma, and Hodgkin's disease	160	58	18	58	3	44
Other and unspecified sites	388	138	40	124	13	165
Heart and circulatory (total)	4, 074	1, 434	560	1, 831	153	2, 044
Coronary heart disease	2, 277	803	324	1, 029	94	1, 205
Other heart diseases	666	235	82	285	19	274
Cerebral vascular lesions	894	313	121	401	31	413
Aortic aneurysm	37	13	12	43	4	60
Other circulatory diseases	200	70	21	73	5	92
All other diseases (total)	754	266	112	360	34	424
Cirrhosis of liver	30	10	5	14	0	—
Pneumonia; influenza	102	35	12	45	2	25
Emphysema	15	6	14	45	8	100
Other diseases	607	215	81	256	24	299
Accidents, violence, suicide	143	51	20	64	2	31
Total death certificates received	6, 414	2, 269	873	2, 827	235	3, 095
Death certificates not yet received	175	62	14	40	4	43
Grand total	6, 589	2, 331	887	2, 867	239	3, 138

Note: See text for definition of "heavier" cigarette smokers.

*Death rate omitted when number of person-years times total death rate for age-sex group yields expected number of less than 10 deaths. In some tables the number for deaths and person-years are shown for completeness.

†Death rate based on small number of observations; the number of person-years times total death rate for age-sex group yields expected number of 4 or more but less than 10 deaths. In some tables the number for deaths and person-years are shown for completeness.

‡Death rate based on small number of observations; the number of person-years times total death rate for age-sex group yields expected number of less than 4 deaths. In some tables the number for deaths and person-years are shown for completeness.

Mortality of British Doctors in Relation to Smoking: Observations on Coronary Thrombosis [1]

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THE study of the effects of smoking among British doctors (Doll and Hill, 1964), like the other prospective studies reviewed in the Report of the Advisory Committee to the Surgeon General of the U.S. Public Health Service (1964), has been based on the observation of mortality rather than morbidity. This limitation was natural and justifiable, since the disease of particular interest that promoted all such inquiries, namely, cancer of the lung, has so high a fatality. It is also, even today, a relatively rare condition and, therefore, very large populations have had to be studied. In these circumstances not only would unbiased morbidity data have been extremely difficult to collect, but even if collected accurately they could not have provided much more useful information than the far more easily collected mortality data.

With the large number of deaths involved—4,597 in our own inquiry and ranging from 1,704 in Dunn, Buell, and Breslow's (1964) study of Californian members of the American Legion and their wives to 24,519 in Dorn's (1964) study of U.S. war veterans—it has not, in most of the investigations, been considered practicable to seek special evidence of the cause of death in each case. Mortality rates have, therefore, been derived from the information given on the standard death certificates required by law. Such information is certainly not completely accurate and any inaccuracy must inevitably blur the picture sought and the contrasts between one disease and another. Thus diseases related to smoking will seem less closely related than in fact they are, since the deaths actually caused by them will be diluted by the erroneous inclusion of a number of deaths due to diseases unrelated to smoking; and diseases unrelated to smoking will show a spurious relationship, because of the inclusion of a number of deaths which were in fact due to other and related diseases.

To reduce this error, special inquiries have sometimes been made about the medical evidence on which the death certificate was based. Hammond and Horn (1958), for example, sought evidence from hospitals whenever

[1] With an Appendix setting out detailed data for all causes of death over a 10-year period.

cancer was mentioned on the death certificate, and we made similar inquiries about all deaths attributed to cancer of the lung. For other diseases, however, no such inquiries have been made, and the underlying cause given on the death certificate has generally been accepted as the cause of death. The only exception is the study of U.S. war veterans made by Dorn (1959). In this study further inquiries were made of the doctor who signed the death certificate whenever death occurred within the United States. Replies were received to 99 percent of the letters and, as a result, in 6 percent the cause of death was changed from that given on the death certificate as the underlying cause. In Dorn's study, moreover, additional information about other diseases present at the time of death was also utilized. One underlying and up to two contributory causes of death were coded and a tabulation was also made of any mention of cancer which the physician stated was present at death, even though it was given as neither a contributory nor the underlying cause. By this means Dorn sought to overcome one of the difficulties associated with the use of the underlying cause of death. As, with reference to the United States, he has pointed out elsewhere (Dorn, 1959) "More than two-thirds of deaths at the present time are attributed to chronic diseases. Usually more than one chronic disease is present at the same time, and even the attending physician has difficulty in deciding which shall be chosen as the primary cause of death." The method of multiple classification fails, however, to account for another difficulty; for, as Dorn continued, "Frequently it is medically unrealistic to select a single disease since death results from the combined effect of two or more." In such cases the maximum information may be obtained only when the interaction between diseases is examined.

In our own study we first attempted such an examination by separately classifying coronary thrombosis and cerebrovascular disease when (*a*) they were said to have been accompanied by hypertension, and (*b*) when they were not (Doll and Hill, 1964). In common with other studies, our results showed a relationship between cigarette smoking and coronary disease, but they failed to show any such relationship with hypertension and none for the small number of cases in which the coronary disease was accompanied by hypertension. We have now studied these deaths from coronary disease in greater detail, taking account of all other recorded associations on the death certificates, and we report here the results for the 1,376 deaths in male doctors attributed to arteriosclerotic heart disease (International Statistical Classification, List No. 420, WHO, 1957) which, for the sake of brevity, we described in our previous paper as due to "coronary disease."

Also, in an Appendix to this present study, we give the detailed observations of the numbers of deaths from different underlying causes, divided according to age at death and the subject's previous smoking history, together with the number of person-years at risk under observation for each age and smoking category subgroup. With these data it is possible to derive nearly all the standardized death rates given in our previous

paper (Doll and Hill, 1964) and to summarize the results in forms that may make them more directly comparable with other studies.

METHOD

The causes of death given on the death certificate were classified along four axes and each death was given a 4-digit code number. The first digit was used to characterize the type of heart disease, the second to characterize the state of the blood vessels (including the presence of hypertension), the third to indicate the presence of disease in other systems, and the fourth to indicate whether there had been a recent operation.

Combinations of conditions which, it was believed, might be of clinical interest were examined, and death rates were calculated for each of these combinations, for various groups of doctors defined by smoking habits and age. By applying these age-specific rates to the 1956 male population of England and Wales, we calculated standardized death rates at all ages (for further details *see* method A, Doll and Hill, 1964).

RESULTS

Table 1 shows the results for 8 categories of disease. One small group consists of 7 deaths which were found on re-examination to have been wrongly attributed to coronary disease;[2] none of them had occurred in continuing cigarette smokers and relatively more had occurred in nonsmokers than in smokers. As might have been anticipated, their misclassification served to blur the distinction between different disease groups; and they have been excluded from all subsequent analyses.

When coronary disease was accompanied by another disease we had found to be related to smoking,[3] its association with smoking habits is close. Despite the small number of deaths (35), the pattern is similar to that shown by these conditions when they were themselves given as the underlying cause of death, though the differences are less marked. The death rate is higher in smokers than in nonsmokers, in continuing smokers than in ex-smokers, and in heavy cigarette smokers than in light smokers. In heavy cigarette smokers the mortality (*0.23 per 1,000*) is nearly 8 times that in nonsmokers (*0.03 per 1,000*). The final category in table 1 shows a distinct association for coronary disease unaccompanied on the death certificate by any other specific disease. For this large group, constituting nearly two-thirds of the total, the pattern of the death rates is similar to that seen when coronary disease is accompanied by one of the conditions related to smoking, but the variation between men with

[2] Details of these cases are given in Appendix table 12 (p 268).

[3] Lung cancer, cancers of the upper respiratory and digestive tracts, chronic bronchitis, peptic ulcer, cirrhosis of the liver and alcoholism, and pulmonary tuberculosis (Doll and Hill, 1964).

TABLE 1.—Death rates from coronary disease, standardized for age; by type of accompanying disease and smoking habits

Cause of death	Number of deaths	Annual death rate per 1,000										
		All men	Non-smokers	All smokers	Smokers			Ex-cigarette smokers	Continuing cigarette smokers			
					Cigarette	Mixed	Pipe or cigar		All amounts	Smoking daily		
										1–14	15–24	25 or more
Coronary disease accompanied by:												
Diseases related to smoking	35	0. 11	0. 03	0. 12	0. 15	0. 09	0. 09	0. 05	0. 19	0. 16	0. 20	0. 23
Diseases "causing" coronary thrombosis	118	0. 37	0. 39	0. 37	0. 34	0. 51	0. 25	0. 24	0. 36	0. 40	0. 39	0. 20
Other significant heart disease	25	0. 08	0. 03	0. 08	0. 06	0. 12	0. 07	0. 05	0. 07	0. 05	0. 10	0. 05
Other systemic disease	99	0. 31	0. 33	0. 30	0. 33	0. 32	0. 17	0. 31	0. 33	0. 41	0. 32	0. 16
General arteriosclerosis	192	0. 59	0. 47	0. 60	0. 62	0. 54	0. 62	0. 38	0. 75	0. 90	0. 60	0. 55
Other vascular disease	35	0. 11	0. 18	0. 10	0. 11	0. 12	0. 06	0. 12	0. 10	0. 00	0. 16	0. 17
Coronary disease unaccompanied by:												
Any other specific disease	865	2. 68	2. 12	2. 77	3. 03	2. 49	2. 13	2. 76	3. 06	2. 72	2. 81	3. 79
All coronary disease	1, 369	4. 24	3. 54	4. 34	4. 64	4. 20	3. 39	3. 90	4. 86	4. 65	4. 57	5. 16
Misclassified	7	0. 02	0. 07	0. 02	0. 01	0. 05	0. 00	0. 02	0. 00	0. 00	0. 00	0. 00
All deaths "attributed to coronary disease"	1, 376	4. 26	3. 61	4. 36	4. 65	4. 25	3. 39	3. 92	4. 86	4. 65	4. 57	5. 16

different smoking habits is much less. Thus, the difference between heavy cigarette smokers (*3.79 per 1,000*) and nonsmokers (*2.12 per 1,000*) is less than twofold.

For two categories the evidence is equivocal, namely, in a small group of 25 deaths in which some other significant heart disease was also present (*i.e.*, valvular disease, constrictive pericarditis, auricular fibrillation, or congestive heart failure as an underlying cause of death), and a larger group of 192 deaths associated with general arteriosclerosis. The death rates are higher in smokers than in nonsmokers, but there is no evidence of any particular association with cigarette smoking or with the amount smoked. The remaining three categories show no relationship with smoking: 1) 118 deaths in which a condition known to predispose to coronary disease was also mentioned on the certificate (hypertension, 91; diabetes mellitus, 25; obesity, 2); 2) 35 deaths accompanied by some other vascular disease (*i.e.*, cerebrovascular disease, aortic aneurysm, pulmonary infarct, thrombosis in another major vessel, or nephritis); and 3) 99 deaths accompanied by another disease outside the cardiovascular system (principally respiratory diseases, cancer, chronic diseases of the central nervous system, or a condition for which an operation had recently been performed). These last 5 categories combined account for about a third of all the deaths attributed to coronary disease and considering them as a whole the death rate of smokers (*1.45 per 1,000*) is only 4 percent more than that of nonsmokers (*1.40*); the rate in cigarette smokers (*1.46*) is less than in mixed smokers (*1.61*) and in heavy cigarette smokers (*1.13*) it is less than in light smokers (*1.76*). The number of deaths in this group is substantial (469) and if there is any relationship with smoking, it is clearly very tenuous.

The 865 deaths for which coronary disease was unassociated with any other specific condition are examined in greater detail in table 2. The majority (555) were attributed to "pure" coronary thrombosis—that is, to coronary thrombosis without any significant qualification.[4] For this group the association with smoking is strong. The death rate of smokers (*1.79 per 1,000*) was 40 percent more than that of nonsmokers (*1.28*), 52 percent more in cigarette smokers (*1.94*), and 109 percent more in heavy continuing cigarette smokers (*2.68*). However, when coronary thrombosis was accompanied by a reference on the death certificate to disease of the coronary artery, the association with smoking was apparently less close and in the two remaining categories it was either very slight or nonexistent—67 deaths in which coronary thrombosis was said to have been accompanied by myocarditis, myocardial degeneration, or cardiovascular degeneration, and 77 deaths which were attributed to angina pectoris, ischemic heart disease, or some synonymous term without reference to a specific episode of thrombosis.

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[4] Defined as coronary thrombosis, infarction or occlusion, or myocardial infarction without qualification other than the addition, as the mode of death, of a recognized complication such as syncope, heart failure, pulmonary edema, ventricular fibrillation, bundle branch block, ruptured heart or peripheral vascular collapse. or of an indefinite cause such as senility.

TABLE 2.—Death rates from coronary disease unaccompanied by any other specific disease, standardized for age: by pathological description and smoking habits

Cause of death	Number of deaths	Annual death rate per 1,000										
		All men	Non-smokers	All smokers	Smokers			Ex-cigarette smokers	Continuing cigarette smokers			
					Cigarette	Mixed	Pipe or cigar		All amounts	Smoking daily		
										1–14	15–24	25 or more
Coronary thrombosis:												
Without significant qualification *	555	1.72	1.28	1.79	1.94	1.56	1.50	1.61	2.03	1.79	1.83	2.68
Qualified only by reference to coronary atheroma, etc.†	166	0.51	0.43	0.53	0.61	0.48	0.32	0.51	0.64	0.63	0.59	0.69
Accompanied by myocarditis, myocardial degeneration, or cardiovascular degeneration	67	0.21	0.20	0.21	0.23	0.22	0.11	0.29	0.20	0.14	0.24	0.19
Coronary disease without reference to thrombosis (*e.g.*, angina, ischemic heart disease)	77	0.24	0.21	0.24	0.24	0.23	0.20	0.34	0.19	0.16	0.16	0.24
All coronary disease, unassociated with any other specific disease	865	2.68	2.12	2.77	3.03	2.49	2.13	2.76	3.06	2.72	2.81	3.79

*See footnote on page 209.

†Coronary atheroma or atherosclerosis, coronary artery disease, angina pectoris, or ischemic heart disease.

When, therefore, we take account of all the information available to us on the death certificate, we can divide the 1,369 deaths attributable to coronary disease into three groups, distinguished by the character of their relationship with smoking. One small group consists of 35 deaths in which the coronary disease was accompanied by one of the other conditions we have previously found related to smoking. The second and largest group consists of 721 deaths in which the coronary thrombosis is qualified only by mention of conditions which may be presumed to be the direct result of the thrombosis or by a reference to disease of the coronary arteries. The third group consists of 613 deaths in which the coronary thrombosis is accompanied by some other disease, including in this category myocarditis and myocardial degeneration, or in which death is attributed to coronary disease without reference to a specific episode of thrombosis. The first and second groups are clearly related to cigarette smoking—the first closely, the second less so—but the third group is either unrelated to smoking or so weakly related as to be of little practical interest.

That these differences are not artifacts produced by the method of age-standardization is shown by comparison of the death rates at individual ages (table 3). In this comparison the first group, coronary thrombosis accompanied by another disease related to smoking, has been omitted, because the number of deaths, 35, is too small for subdivision. In the second group we see that the relationship with smoking is present at all ages under 75. It is, however, much closer at younger ages than at older, and the ratio between the rates in heavy continuing cigarette smokers and in nonsmokers is reduced from tenfold at ages 35 to 44 and nearly fourfold at 45 to 54 to double or less at ages over 55. In the third group the pattern is irregular; at young ages the highest death rates are observed in heavy continuing cigarette smokers, but there is no consistent difference between the rates of nonsmokers and cigarette smokers, and if there is any relationship with smoking it is clearly not important. While a larger proportion of these deaths occurred in men over 75, they were by no means wholly confined to these ages and there is a clear distinction between the two large groups at ages under 55.

DISCUSSION

It is not our purpose in this paper to assess the meaning of the relationship between coronary thrombosis and cigarette smoking and to decide whether smoking should be regarded as a cause of the disease. This has recently been considered elsewhere (*i.e.*, Report of the Advisory Committee to the Surgeon General of the U.S. Public Health Service, 1964; Doll and Hill, 1964). We have, rather, limited ourselves to determining whether in such circumstances any useful knowledge can be obtained by examining all the other information on a death certificate apart from the underlying cause of death. This was something which

TABLE 3.—Age-specific death rates from different types of coronary disease: by smoking habits (numbers of deaths in parentheses)

Age (years)	Annual death rate per 1,000									
	Coronary thrombosis without reference to other disease*					Other coronary disease†				
	Non-smokers	Smokers	Cigarette smokers	Continuing cigarette smokers		Non-smokers	Smokers	Cigarette smokers	Continuing cigarette smokers	
				All amounts	25 or more/day				All amounts	25 or more/day
35–44	(2) 0. 11	(27) 0. 36	(23) 0. 44	(23) 0. 52	(10) 1. 07	(—) —	(10) 0. 13	(10) 0. 19	(8) 0. 18	(4) 0. 43
45–54	(6) 0. 56	(111) 1. 72	(84) 1. 94	(74) 2. 14	(21) 1. 98	(7) 0. 66	(37) 0. 57	(25) 0. 58	(25) 0. 72	(12) 1. 13
55–64	(20) 3. 50	(195) 4. 12	(138) 4. 82	(108) 4. 98	(37) 5. 52	(11) 1. 93	(112) 2. 37	(76) 2. 66	(60) 2. 77	(24) 3. 58
65–74	(15) 5. 80	(186) 7. 03	(96) 7. 58	(71) 8. 07	(23) 10. 65	(17) 6. 58	(182) 6. 88	(91) 7. 19	(64) 7. 27	(11) 5. 09
75–84	(11) 7. 52	(122) 9. 38	(46) 8. 65	(29) 8. 55	(7) 15. 14	(19) 12. 99	(166) 12. 77	(59) 11. 10	(37) 10. 91	(1) 2. 16
85 or over	(4) 11. 76	(22) 9. 21	(12) 14. 37	(5) 11. 56	(0) —‡	(6) 17. 65	(46) 19. 27	(17) 20. 36	(11) 25. 43	(0) —‡
All ages standardized	(58) 1. 71	(663) 2. 32	(399) 2. 55	(310) 2. 67	(98) 3. 37	(60) 1. 81	(553) 1. 90	(278) 1. 93	(205) 2. 00	(52) 1. 56

*See text, group 2.
†Excluding coronary disease accompanied by other diseases related to smoking; see text, group 3.
‡Very few men observed in this category, total man-years at risk 28.

Harold Dorn greatly desired, and it is through knowledge of his interest that we have been stimulated to make this inquiry.

Certain aspects of the results are impressive. First, they provide confirmation that diseases, other than coronary thrombosis, can be divided into two distinct groups—of which one is closely related to smoking and the other is not. In this present study there were only 35 deaths in which mention was made of a disease in one of the other six groups of diseases related to smoking habits, but, despite these small numbers, the relationship with smoking within this group was qualitatively different from the very indefinite relationship revealed by the 613 cases in which death from coronary thrombosis was said to have been accompanied by some other condition.

Secondly, our results suggest that a relationship with smoking is characteristic of only little more than one half the total number of deaths attributed to coronary thrombosis. Possibly, many of the deaths in the unrelated group were not due to, or even accompanied by, coronary thrombosis. We did not inquire about the nature of the evidence on which the diagnosis was made and the diagnosis may sometimes have been erroneous—particularly perhaps at the oldest ages. It seems unlikely, however, that misdiagnosis could have occurred in a sufficiently large proportion of the cases to have been responsible for the results.

If we may assume that the diagnosis was correct in at least the majority of cases in each group, then it would seem to follow that correspondingly there must be at least two principal groups of causes of the disease. In the first cause-group, cigarette smoking may be an important component, particularly when death occurs under 55. The second cause-group would appear to be quite different, with the existence of some other pathological condition as one component. That hypertension and diabetes should be such a condition would have been expected on the basis of a great deal of clinical and epidemiological evidence; it would, however, appear from these results that coronary thrombosis may also arise as a secondary complication, in some cases perhaps only a terminal one, of a whole range of other conditions—varying from other heart disease and cerebrovascular accidents, to bronchitis, cancer, and abdominal operations. If this is true, the relationship with smoking revealed by the small number of deaths in which coronary thrombosis was accompanied by one of the "related diseases" can be regarded as merely a secondary one, dependent on the relationship of the accompanying disease.

Thirdly, our figures provide some confirmation of the finding by Doyle, Dawber, Kannel, Heslin, and Kahn (1962) that the relationship with smoking is confined to cases of coronary disease accompanied by a specific episode of thrombosis. In their study also angina pectoris alone, in the absence of thrombosis, was independent of smoking.

If further study should confirm that coronary thrombosis is unrelated, or, only faintly related to smoking when it occurs in the presence of some other disease, possibly such other disease must itself be associated with a substantially increased risk of developing coronary thrombosis. Hyper-

tension or a disordered carbohydrate metabolism apparently cannot wholly account for the findings and other, possibly more general factors, must be postulated. Such factors may include physical inactivity (Morris, Heady, Raffle, Roberts, and Park, 1953), disturbance in blood chemistry related to a raised erythrocyte sedimentation rate, and increased plasma hypercoagulability found in patients with carcinoma or after hemorrhage (Eastham and Morgan, 1964).

SUMMARY

Classification of deaths according to the "underlying cause" on the standard international death certificate may result in the loss of useful information. Two or more diseases frequently occur at the same time in the same individual and interaction between diseases may be a factor in causing death.

In a follow-up investigation of British doctors whose smoking habits had been previously recorded, there were 1,376 deaths in the course of 10 years in which the "underlying cause" was coronary disease. These deaths have been re-examined and reclassified according to any combination of diseases referred to on the death certificate.

Excluding 7 deaths wrongly attributed to coronary disease, the remainder were classified into 3 groups: 1) 35 in which coronary thrombosis was accompanied by one or other of the diseases previously found to be related to cigarette smoking; these were themselves closely related to cigarette smoking; 2) 721 in which coronary thrombosis was unqualified, or qualified only by reference to a condition that was presumably the result of the thrombosis; these showed a clear relationship with cigarette smoking; and 3) 613 in which coronary thrombosis was accompanied by some other disease, or in which death was attributed to coronary disease without reference to a specific episode of thrombosis; these were unrelated to cigarette smoking or showed only a weak relationship.

It is concluded that cigarette smoking is a factor which contributes, in a large group of cases, to death from coronary thrombosis, and that the presence of some other disease contributes to death in another large group.

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APPENDIX

In a previous report we gave the mortality rates from different causes observed over a 10-year period among groups of British doctors with different smoking habits (Doll and Hill, 1964). Within the limits of the report it was not possible to present the detailed observations from which the rates were derived, and the results were, for the most part, expressed as standardized rates, with the 1956 male population of England and Wales used as the standard population. The data from which these rates were derived are now set out in Appendix tables 1 through 12. The numbers of person-years at risk and of deaths from different causes are given in 5-year age groups, although they were combined into 10-year age groups (25–34, 35–44, 45–54, 55–64, 65–74, and 75 and over) before the standardized rates were calculated, because of the small numbers of deaths from many of the individual causes in some of the smoking categories.

Data are given separately for all the causes referred to in our previous publication except that: (*a*) 97 deaths from cancer of the bowel (International List Nos. 152 and 153) have been combined with the 35 deaths from cancer of the rectum (List No. 154), and (*b*) 82 deaths from genitourinary diseases other than nephritis (List Nos. 600–647) have been combined with 50 deaths from indefinite causes (List Nos. 780–795, excluding 784.5) and with 150 deaths from all remaining causes not included in any other category. The disease categories used are defined as:

Disease group	*International List Nos.*
Cancer of the lung	162, 163, less cancer of the trachea
Cancer of the upper respiratory and digestive tracts	140–148, 150, 160, 161, plus cancer of the trachea
Chronic bronchitis	502, 527.1
Pulmonary tuberculosis	001–008
Coronary disease	420, less deaths where hypertension was referred to as a contributory cause
Peptic ulcer	540–542, 784.5
Cirrhosis of the liver and alcoholism	581, 322
Cancer of the bladder	181
Cancer of the stomach	151
Cancer of the bowel and rectum	152–154
Cancer of other primary sites	All other 140–237, less 199
Cancer, primary site unknown	199
Other respiratory disease	470–527, less 502 and 527.1
Cerebrovascular accidents	330–334, less deaths where hypertension was referred to as a contributory
Myocardial degeneration	cause 422
Hypertension	440–447, plus deaths excluded from 420 and 330–334
Other heart disease	All other 400–434
Other cardiovascular disease	450–468
Nephritis	590–594
Other digestive disease	All other 530–587
Violence	E800–E999
All other causes	All others

Calculations based on the data in these tables may occasionally lead to results slightly different from those published previously, because (*a*) person-years at risk (originally calculated to the nearest half year or, in table 5, to the nearest quarter year) have been rounded off to units, and (*b*) a few errors have been corrected. One death in the first quinquennium attributed to coronary disease without reference to hypertension has been deducted from 1) current cigarette smokers, and 2) all men aged 55–59 years, and one death in the second quinquennium, attributed to "unrelated causes," has been deducted from 1) all men aged 35–39 years, and 2) all men aged 60–64 years. One death has been added to 1) all men aged 35–39 years attributed to "other related causes" in the second quinquennium, 2) all men aged 55–59 years attributed to "unrelated causes" in the first quinquennium, and 3) all men aged 65–69 years attributed to "unrelated causes" in the second quinquennium (table 2). One death attributed to related causes has been deducted from current pipe and cigar smokers aged 65–69 years and transferred to the age group 75 years and over. One death attributed to related causes has been added to current cigarette smokers, smoking 25 or more a day, aged 45–49 years (table 5).

In tables 1, 2, 3, and 4 the deaths have been related to the information about smoking habits obtained in response to our first (1951) questionnaire, and no attention has been paid to later information obtained from a second questionnaire in 1957 (method of analysis A). In table 5 information about changes in smoking habits recorded in the second questionnaire has been taken into account in calculation of the man-years at risk in the different smoking categories for the 3 years, 1958–61. Deaths occurring before 1 November, 1958, have, therefore, been related to the information obtained in the first questionnaire and later deaths have been related to the later information (method of analysis B). Table 6 relates to information given only in response to the second questionnaire, so that the man-years at risk could be calculated only from 1 November, 1958 (method of analysis C). Since the number of deaths attributed to any one cause in a 3-year period is small, the data have been increased by extension of the observation period for a further year (1 November, 1961, to 31 October, 1962). In table 7, the woman-years at risk have been calculated by method A, but because of the small numbers of deaths the period of observation has been extended to 11 years.

Tables 3 and 4 provide figures for man-years at risk, which allow special calculations to be made for lung cancer mortality by use of the information about deaths recorded in table 8.

Appendix table 1.—Number of person-years at risk, by age, and number of deaths, by age and cause, according to selected smoking habit characteristics. British doctors, males, 1951–61

	All ages	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85 and over
	TOTAL MALES													
Number of person-years at risk	320, 185	15, 371	36, 079	47, 640	46, 653	40, 001	35, 155	30, 565	22, 483	16, 404	12, 643	8, 979	5, 485	2, 727
Number of deaths:														
All causes	4, 597	14	44	86	97	161	311	407	469	506	604	683	644	571
Related causes,* total	1, 775	—	—	21	32	65	134	220	244	239	283	259	176	102
Cancer of the lung	207	—	—	2	3	5	17	31	40	31	32	26	15	5
Cancer of the upper respiratory and digestive tracts	56	—	—	—	—	1	4	5	11	13	3	9	7	3
Chronic bronchitis	111	—	—	—	—	1	4	6	14	9	22	28	17	10
Pulmonary tuberculosis	42	—	—	2	3	1	6	9	4	4	6	4	2	1
Coronary disease†	1, 287	—	—	14	24	53	96	154	165	177	212	184	130	78
Peptic ulcer	39	—	—	—	—	2	3	4	5	2	7	6	5	5
Cirrhosis of the liver and alcoholism	33	—	—	3	2	2	4	11	5	3	1	2	—	—
Unrelated causes,‡ total	2, 822	14	44	65	65	96	177	187	225	267	321	424	468	469
Cancer of the bladder	36	—	—	—	—	1	1	1	3	4	3	11	9	3
Cancer of the stomach	84	—	—	2	—	5	5	8	9	6	16	12	14	7
Cancer of the bowel and rectum	132	1	1	4	2	4	12	8	17	22	11	13	17	20
Cancer of the prostate	69	—	—	—	—	1	1	2	4	5	15	13	20	8
Cancer, other primary site	194	5	7	10	13	12	19	14	24	28	26	22	10	4
Cancer, primary site unknown	27	—	—	—	2	1	1	1	4	2	6	5	3	2
Other respiratory disease	181	—	1	3	—	3	12	10	6	11	19	26	44	46
Cerebrovascular accidents†	462	—	—	3	3	6	13	23	26	41	70	103	98	76
Myocardial degeneration	337	—	—	2	—	1	2	4	9	10	24	60	92	133
Hypertension†	370	—	1	3	8	12	40	54	50	58	48	47	28	21
Other heart disease	135	—	1	2	2	7	4	8	7	13	20	22	25	24
Other cardiovascular disease	135	1	1	—	1	1	5	8	14	21	10	20	24	29
Nephritis	43	—	2	1	1	3	6	1	4	6	3	5	4	7
Other digestive disease	87	—	—	—	6	1	9	8	2	5	8	17	15	16
Violence	248	6	23	24	21	28	35	24	15	14	13	8	17	20
All other causes	282	1	7	11	6	10	12	13	31	21	29	40	48	53

	MALE NONSMOKERS †													
Number of person-years at risk	54, 660	5, 138	9, 962	10, 470	8, 320	6, 133	4, 540	3, 437	2, 273	1, 495	1, 090	855	607	340
Number of deaths:														
All causes	436	3	14	14	7	16	28	40	29	36	43	65	56	85
Related causes,* total	120	—	—	2	1	4	9	17	11	10	20	22	13	11
Cancer of the lung	3	—	—	1	—	—	—	—	—	—	—	2	—	—
Cancer of the upper respiratory and digestive tracts	1	—	—	—	—	—	—	—	—	—	1	—	—	—
Chronic bronchitis	2	—	—	—	—	—	—	—	—	—	—	1	1	—
Pulmonary tuberculosis	2	—	—	—	—	—	1	—	—	—	1	—	—	—
Coronary disease†	112	—	—	1	1	4	8	17	11	10	18	19	12	11
Peptic ulcer	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cirrhosis of the liver and alcoholism	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Unrelated causes,‡ total	316	3	14	12	6	12	19	23	18	26	23	43	43	74
Cancer of the bladder	6	—	—	—	—	—	—	—	—	—	1	2	2	1
Cancer of the stomach	10	—	—	—	—	1	1	2	—	1	—	2	2	1
Cancer of the bowel and rectum	13	—	—	1	—	—	—	—	—	2	—	3	3	4
Cancer of the prostate	11	—	—	—	—	—	—	—	1	3	—	3	1	3
Cancer, other primary site	27	1	2	5	1	4	2	2	2	3	2	1	2	—
Cancer, primary site unknown	4	—	—	—	1	—	—	—	1	—	—	—	—	2
Other respiratory disease	23	—	—	1	—	—	2	1	1	3	—	2	5	8
Cerebrovascular accidents†	44	—	—	—	—	1	2	1	1	2	4	8	9	16
Myocardial degeneration	21	—	—	—	—	—	—	—	1	—	2	3	2	13
Hypertension†	42	—	1	1	—	1	3	8	5	6	7	4	4	2
Other heart disease	16	—	—	1	—	—	1	2	1	—	—	4	2	5
Other cardiovascular disease	16	—	—	—	1	1	1	—	1	—	—	5	1	6
Nephritis	4	—	1	—	1	—	—	—	—	—	1	1	—	—
Other digestive disease	3	—	—	—	—	—	2	—	1	—	—	—	—	—
Violence	40	2	9	2	1	4	4	5	1	4	2	—	3	3
All other causes	36	—	1	1	1	—	1	2	2	2	4	5	7	10

See footnotes at end of Appendix table 1.

APPENDIX TABLE 1.—Number of person-years at risk, by age, and number of deaths, by age and cause, according to selected smoking habit characteristics. British doctors, males, 1951–61—Continued

	All ages	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85 and over
	MALE SMOKERS†													
Number of person-years at risk	265, 525	10, 233	26, 117	37, 170	38, 333	33, 868	30, 615	27, 128	20, 210	14, 909	11, 553	8, 124	4, 878	2, 387
Number of deaths:														
All causes	4, 161	11	30	72	90	145	283	367	440	470	561	618	588	486
Related causes,* total	1, 655	—	—	19	31	61	125	203	233	229	263	237	163	91
Cancer of the lung	204	—	—	1	3	5	17	31	40	31	32	24	15	5
Cancer of the upper respiratory and digestive tracts	55	—	—	—	—	1	4	5	11	13	2	9	7	3
Chronic bronchitis	109	—	—	—	—	1	4	6	14	9	22	27	16	10
Pulmonary tuberculosis	40	—	—	2	3	1	5	9	4	4	5	4	2	1
Coronary disease†	1, 175	—	—	13	23	49	88	137	154	167	194	165	118	67
Peptic ulcer	39	—	—	—	—	2	3	4	5	2	7	6	5	5
Cirrhosis of the liver and alcoholism	33	—	—	3	2	2	4	11	5	3	1	2	—	—
Unrelated causes,‡ total	2, 506	11	30	53	59	84	158	164	207	241	298	381	425	395
Cancer of the bladder	30	—	—	—	—	1	1	1	3	4	2	9	7	2
Cancer of the stomach	74	—	—	2	—	4	4	6	9	5	16	10	12	6
Cancer of the bowel and rectum	119	1	1	3	2	4	12	8	17	20	11	10	14	16
Cancer of the prostate	58	—	—	—	—	1	1	2	3	2	15	10	19	5
Cancer, other primary site	167	4	5	5	12	8	17	12	22	25	24	21	8	4
Cancer, primary site unknown	23	—	—	—	1	1	1	1	3	2	6	5	3	—
Other respiratory disease	158	—	1	2	—	3	10	9	5	8	19	24	39	38
Cerebrovascular accidents†	418	—	—	3	3	5	11	22	25	39	66	95	89	60
Myocardial degeneration	316	—	—	2	—	1	2	4	8	10	22	57	90	120
Hypertension†	328	—	—	2	8	11	37	46	45	52	41	43	24	19
Other heart disease	119	—	1	1	2	7	3	6	6	13	20	18	23	19
Other cardiovascular disease	119	1	1	—	—	—	4	8	13	21	10	15	23	23
Nephritis	39	—	1	1	—	3	6	1	4	6	2	4	4	7
Other digestive disease	84	—	—	—	6	1	7	8	1	5	8	17	15	16
Violence	208	4	14	22	20	24	31	19	14	10	11	8	14	17
All other causes	246	1	6	10	5	10	11	11	29	19	25	35	41	43

	MALE CIGARETTE SMOKERS†													
Number of person-years at risk	168, 810	7, 295	18, 433	25, 897	26, 510	23, 105	20, 143	17, 030	11, 582	7, 410	5, 253	3, 422	1, 895	835
Number of deaths:														
All causes	2, 246	10	21	52	69	109	198	249	298	274	291	252	248	175
Related causes,* total	958	—	—	15	27	49	97	146	160	134	136	95	60	39
Cancer of the lung	139	—	—	—	2	5	15	21	31	21	21	14	8	1
Cancer of the upper respiratory and digestive tracts	22	—	—	—	—	—	2	3	5	8	1	2	—	1
Chronic bronchitis	69	—	—	—	—	1	4	4	9	7	16	16	7	5
Pulmonary tuberculosis	26	—	—	1	3	1	4	8	3	2	1	—	2	1
Coronary disease†	660	—	—	12	20	38	66	101	105	93	93	59	43	30
Peptic ulcer	20	—	—	—	—	2	2	3	4	2	3	3	—	1
Cirrhosis of the liver and alcoholism	22	—	—	2	2	2	4	6	3	1	1	1	—	—
Unrelated causes,‡ total	1, 288	10	21	37	42	60	101	103	138	140	155	157	188	136
Cancer of the bladder	16	—	—	—	—	1	—	—	2	2	—	6	4	1
Cancer of the stomach	43	—	—	2	—	4	2	2	8	2	8	4	7	4
Cancer of the bowel and rectum	56	1	—	3	1	2	8	5	5	14	6	3	5	3
Cancer of the prostate	24	—	—	—	—	—	—	2	3	1	8	5	5	—
Cancer, other primary site	103	4	4	5	7	5	11	7	18	13	13	9	5	2
Cancer, primary site unknown	8	—	—	—	—	1	—	—	3	—	—	3	1	—
Other respiratory disease	76	—	—	2	—	2	8	6	4	4	10	12	16	12
Cerebrovascular accidents†	199	—	—	3	3	3	6	14	11	25	36	40	39	19
Myocardial degeneration	133	—	—	2	—	1	2	3	6	7	10	18	42	42
Hypertension†	185	—	—	1	7	7	24	31	33	30	22	15	13	2
Other heart disease	57	—	1	1	—	6	2	2	4	6	12	8	10	5
Other cardiovascular disease	62	1	1	—	—	—	1	5	10	12	4	6	14	8
Nephritis	21	—	1	1	—	3	3	—	4	3	—	2	1	3
Other digestive disease	47	—	—	—	5	1	5	6	—	2	5	7	9	7
Violence	129	4	12	11	17	17	20	13	8	6	5	3	5	8
All other causes	129	—	2	6	2	7	9	7	19	13	16	16	12	20

See footnotes at end of Appendix table 1.

APPENDIX TABLE 1.—Number of person-years at risk, by age, and number of deaths, by age and cause, according to selected smoking habit characteristics. British doctors, males, 1951–61—Continued

	All ages	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85 and over
	MALE MIXED SMOKERS†§													
Number of person-years at risk	57,507	1,655	4,407	6,580	7,050	6,548	6,577	6,478	5,535	4,652	3,650	2,435	1,330	610
Number of deaths:														
All causes	1,066	—	3	14	11	23	61	79	95	141	164	192	165	118
Related causes,* total	429	—	—	2	2	7	20	40	53	63	79	81	53	29
Cancer of the lung	41	—	—	1	1	—	2	6	5	5	7	7	5	2
Cancer of the upper respiratory and digestive tracts	22	—	—	—	—	—	2	1	5	5	1	2	4	2
Chronic bronchitis	28	—	—	—	—	—	—	1	5	1	5	10	4	2
Pulmonary tuberculosis	9	—	—	—	—	—	—	—	1	2	3	3	—	—
Coronary disease†	312	—	—	—	1	7	15	26	35	49	59	59	40	21
Peptic ulcer	9	—	—	—	—	—	1	1	1	—	4	—	—	2
Cirrhosis of the liver and alcoholism	8	—	—	1	—	—	—	5	1	1	—	—	—	—
Unrelated causes,‡ total	637	—	3	12	9	16	41	39	42	78	85	111	112	89
Cancer of the bladder	8	—	—	—	—	—	1	1	1	2	1	—	2	—
Cancer of the stomach	11	—	—	—	—	—	2	2	1	1	1	3	1	—
Cancer of the bowel and rectum	35	—	—	—	1	1	2	2	7	5	5	6	3	3
Cancer of the prostate	13	—	—	—	—	1	—	—	—	1	3	3	4	1
Cancer, other primary site	40	—	—	—	3	1	3	3	—	12	8	8	1	1
Cancer, primary site unknown	7	—	—	—	1	—	—	—	—	—	3	2	1	—
Other respiratory disease	41	—	—	—	—	1	2	3	1	3	7	4	9	11
Cerebrovascular accidents†	106	—	—	—	—	2	3	4	11	9	14	28	22	13
Myocardial degeneration	87	—	—	—	—	—	—	1	2	2	8	16	26	32
Hypertension†	90	—	—	—	—	3	12	11	6	17	15	11	10	5
Other heart disease	36	—	—	—	1	—	—	4	2	7	6	5	7	4
Other cardiovascular disease	32	—	—	—	—	—	—	3	2	7	4	5	4	7
Nephritis	10	—	—	—	—	—	3	—	—	2	—	2	1	2
Other digestive disease	16	—	—	—	—	—	2	1	1	2	2	4	3	1
Violence	44	—	1	9	1	5	9	3	2	4	3	3	3	1
All other causes	61	—	2	3	2	2	2	1	6	4	5	11	15	8

	MALE PIPE AND CIGAR SMOKERS †													
Number of person-years at risk	39, 208	1, 283	3, 277	4, 693	4, 773	4, 215	3, 895	3, 620	3, 093	2, 847	2, 650	2, 267	1, 653	942
Number of deaths:														
All causes	849	1	6	6	10	13	24	39	47	55	106	174	175	193
Related causes,† total	268	—	—	2	2	5	8	17	20	32	48	61	50	23
Cancer of the lung	24	—	—	—	—	—	—	4	4	5	4	3	2	2
Cancer of the upper respiratory and digestive tracts	11	—	—	—	—	1	—	1	1	—	—	5	3	—
Chronic bronchitis	12	—	—	—	—	—	—	1	—	1	1	1	5	3
Pulmonary tuberculosis	5	—	—	1	—	—	1	1	—	—	1	1	—	—
Coronary disease †	203	—	—	1	2	4	7	10	14	25	42	47	35	16
Peptic ulcer	10	—	—	—	—	—	—	—	—	—	—	3	5	2
Cirrhosis of the liver and alcoholism	3	—	—	—	—	—	—	—	1	1	—	1	—	—
Unrelated causes,‡ total	581	1	6	4	8	8	16	22	27	23	58	113	125	170
Cancer of the bladder	6	—	—	—	—	—	—	—	—	—	1	3	1	1
Cancer of the stomach	20	—	—	—	—	—	—	2	—	2	7	3	4	2
Cancer of the bowel and rectum	28	—	1	—	—	1	2	1	5	1	—	1	6	10
Cancer of the prostate	21	—	—	—	—	—	1	—	—	—	4	2	10	4
Cancer, other primary site	24	—	1	—	2	2	3	2	4	—	3	4	2	1
Cancer, primary site unknown	8	—	—	—	—	—	1	1	—	2	3	—	1	—
Other respiratory disease	41	—	1	—	—	—	—	—	—	1	2	8	14	15
Cerebrovascular accidents †	113	—	—	—	—	—	2	4	3	5	16	27	28	28
Myocardial degeneration	96	—	—	—	—	—	—	—	—	1	4	23	22	46
Hypertension †	53	—	—	1	1	1	1	4	6	5	4	17	1	12
Other heart disease	26	—	—	—	1	1	1	—	—	—	2	5	6	10
Other cardiovascular disease	25	—	—	—	—	—	3	—	1	2	2	4	5	8
Nephritis	8	—	—	—	—	—	—	1	—	1	2	—	2	2
Other digestive disease	21	—	—	—	1	—	—	1	—	1	1	6	3	8
Violence	35	—	1	2	2	2	2	3	4	—	3	2	6	8
All other causes	56	1	2	1	1	1	—	3	4	2	4	8	14	15

See footnotes at end of Appendix table 1.

APPENDIX TABLE 1.—Number of person-years at risk, by age, and number of deaths, by age and cause, according to selected smoking habit characteristics. British doctors, males, 1951–61—Continued

	All ages	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85 and over
	MALE SMOKERS STOPPED †													
Number of person-years at risk	49, 902	855	2, 947	5, 258	6, 313	6, 201	6, 120	5, 777	4, 746	3, 884	3, 122	2, 292	1, 539	848
Number of deaths:														
All causes	1, 044	—	3	12	12	30	36	62	91	96	148	192	184	178
Related causes,* total	372	—	—	2	3	8	10	33	45	50	70	68	50	33
Cancer of the lung	19	—	—	1	1	—	1	1	3	5	4	1	1	1
Cancer of the upper respiratory and digestive tracts	9	—	—	—	—	—	—	—	2	1	—	3	3	—
Chronic bronchitis	31	—	—	—	—	—	2	1	4	2	6	9	7	—
Pulmonary tuberculosis	9	—	—	—	1	—	1	3	2	—	1	1	—	—
Coronary disease†	295	—	—	1	1	8	6	26	34	42	56	53	38	30
Peptic ulcer	7	—	—	—	—	—	—	1	—	—	2	1	1	2
Cirrhosis of the liver and alcoholism	2	—	—	—	—	—	—	1	—	—	1	—	—	—
Unrelated causes,‡ total	672	—	3	10	9	22	26	29	46	46	78	124	134	145
Cancer of the bladder	7	—	—	—	—	—	—	—	—	—	1	1	4	1
Cancer of the stomach	14	—	—	1	—	1	—	1	—	1	2	1	4	3
Cancer of the bowel and rectum	27	—	—	—	—	2	2	1	3	1	4	3	3	8
Cancer of the prostate	22	—	—	—	—	1	—	—	2	1	7	3	5	3
Cancer, other primary site	34	—	1	1	2	4	4	1	4	3	2	5	4	3
Cancer, primary site unknown	4	—	—	—	—	—	—	—	—	—	2	2	—	—
Other respiratory disease	50	—	1	—	—	2	2	2	1	3	5	7	13	14
Cerebrovascular accidents†	129	—	—	—	—	1	—	7	10	8	19	33	32	19
Myocardial degeneration	93	—	—	—	—	—	—	2	1	1	3	20	25	41
Hypertension†	83	—	—	1	3	2	6	8	7	15	14	13	9	5
Other heart disease	38	—	—	1	2	—	—	1	2	3	5	8	9	7
Other cardiovascular disease	26	—	—	—	—	—	1	2	2	1	2	4	6	8
Nephritis	11	—	—	—	—	1	2	—	1	2	—	1	2	2
Other digestive disease	25	—	—	—	1	—	2	—	1	—	3	4	6	8
Violence	38	—	1	4	1	5	5	3	3	2	2	4	2	6
All other causes	71	—	—	2	—	3	2	1	9	5	7	15	10	17

	MALE SMOKERS CONTINUING †													
Number of person-years at risk	215, 623	9, 378	23, 170	31, 912	32, 020	27, 667	24, 495	21, 351	15, 464	11, 025	8, 431	5, 832	3, 339	1, 539
Number of deaths:														
All causes	3, 117	11	27	60	78	115	247	305	349	374	413	426	404	308
Related causes,* total	1, 283	—	—	17	28	53	115	170	188	179	193	169	113	58
Cancer of the lung	185	—	—	—	2	5	16	30	37	26	28	23	14	4
Cancer of the upper respiratory and digestive tracts	46	—	—	—	—	1	4	5	9	12	2	6	4	3
Chronic bronchitis	78	—	—	—	—	1	2	5	10	7	16	18	9	10
Pulmonary tuberculosis	31	—	—	2	2	1	4	6	2	4	4	3	2	1
Coronary disease †	880	—	—	12	22	41	82	111	120	125	138	112	80	37
Peptic ulcer	32	—	—	—	—	2	3	3	5	2	5	5	4	3
Cirrhosis of the liver and alcoholism	31	—	—	3	2	2	4	10	5	3	—	2	—	—
Unrelated causes,‡ total	1, 834	11	27	43	50	62	132	135	161	195	220	257	291	250
Cancer of the bladder	23	—	—	—	—	1	1	1	3	4	1	8	3	1
Cancer of the stomach	60	—	—	1	—	3	4	5	9	4	14	9	8	3
Cancer of the bowel and rectum	92	1	1	3	2	2	10	7	14	19	7	7	11	8
Cancer of the prostate	36	—	—	—	—	—	1	2	1	1	8	7	14	2
Cancer, other primary site	133	4	4	4	10	4	13	11	18	22	22	16	4	1
Cancer, primary site unknown	19	—	—	—	1	1	1	1	3	2	4	3	3	—
Other respiratory disease	108	—	—	2	—	1	8	7	4	5	14	17	26	24
Cerebrovascular accidents †	289	—	—	3	3	4	11	15	15	31	47	62	57	41
Myocardial degeneration	223	—	—	2	—	1	2	2	7	9	19	37	65	79
Hypertension †	245	—	—	1	5	9	31	38	38	37	27	30	15	14
Other heart disease	81	—	1	—	—	7	3	5	4	10	15	10	14	12
Other cardiovascular disease	93	1	1	—	—	—	3	6	11	20	8	11	17	15
Nephritis	28	—	1	1	—	2	4	1	3	4	2	3	2	5
Other digestive disease	59	—	—	—	5	1	5	8	—	5	5	13	9	8
Violence	170	4	13	18	19	19	26	16	11	8	9	4	12	11
All other causes	175	1	6	8	5	7	9	10	20	14	18	20	31	26

See footnotes at end of Appendix table 1.

APPENDIX TABLE 1.—Number of person-years at risk, by age, and number of deaths, by age and cause, according to selected smoking habit characteristics. British doctors, males, 1951–61—Continued

	All ages	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85 and over
	MALE CIGARETTE SMOKERS STOPPED†													
Number of person-years at risk	32, 542	602	2, 053	3, 680	4, 492	4, 378	4, 225	3, 915	3, 010	2, 215	1, 645	1, 155	770	402
Number of deaths:														
All causes	539	—	2	5	8	23	20	41	57	56	78	76	92	81
Related causes,* total	196	—	—	1	2	7	5	24	31	27	37	26	21	15
Cancer of the lung	10	—	—	—	—	—	—	—	3	3	2	1	1	—
Cancer of the upper respiratory and digestive tracts	2	—	—	—	—	—	—	—	1	1	—	—	—	—
Chronic bronchitis	16	—	—	—	—	—	2	1	2	1	4	3	3	—
Pulmonary tuberculosis	5	—	—	—	1	—	—	3	1	—	—	—	—	—
Coronary disease†	157	—	—	1	1	7	3	19	24	22	28	21	17	14
Peptic ulcer	5	—	—	—	—	—	—	1	—	—	2	1	—	1
Cirrhosis of the liver and alcoholism	1	—	—	—	—	—	—	—	—	—	1	—	—	—
Unrelated causes,‡ total	343	—	2	4	6	16	15	17	26	29	41	50	71	66
Cancer of the bladder	4	—	—	—	—	—	—	—	—	—	—	1	2	1
Cancer of the stomach	12	—	—	1	—	1	—	—	—	1	2	1	3	3
Cancer of the bowel and rectum	11	—	—	—	—	1	2	1	—	1	1	—	3	2
Cancer of the prostate	9	—	—	—	—	—	—	—	2	—	5	1	1	—
Cancer, other primary site	21	—	1	1	2	2	2	—	3	3	2	2	2	1
Cancer, primary site unknown	2	—	—	—	—	—	—	—	—	—	—	2	—	—
Other respiratory disease	27	—	—	—	—	1	1	1	1	3	2	2	8	8
Cerebrovascular accidents†	63	—	—	—	—	1	—	4	4	6	9	14	17	8
Myocardial degeneration	41	—	—	—	—	—	—	1	—	1	2	7	15	15
Hypertension†	45	—	—	—	2	2	4	5	5	8	7	6	6	—
Other heart disease	18	—	—	1	—	—	—	1	1	1	3	4	5	2
Other cardiovascular disease	12	—	—	—	—	—	—	1	1	—	—	2	3	5
Nephritis	3	—	—	—	—	1	—	—	1	1	—	—	—	—
Other digestive disease	14	—	—	—	1	—	1	—	—	—	2	2	3	5
Violence	24	—	1	1	1	5	4	2	2	—	1	1	1	5
All other causes	37	—	—	—	—	2	1	1	6	4	5	5	2	11

	MALE CIGARETTE SMOKERS CONTINUING †													
Number of person-years at risk	136, 268	6, 693	16, 380	22, 217	22, 018	18, 727	15, 918	13, 115	8, 572	5, 195	3, 608	2, 267	1, 125	433
Number of deaths:														
All causes	1, 707	10	19	47	61	86	178	208	241	218	213	176	156	94
Related causes,* total	762	—	—	14	25	42	92	122	129	107	99	69	39	24
Cancer of the lung	129	—	—	—	2	5	15	21	28	18	19	13	7	1
Cancer of the upper respiratory and digestive tracts	20	—	—	—	—	—	2	3	4	7	1	2	—	1
Chronic bronchitis	53	—	—	—	—	1	2	3	7	6	12	13	4	5
Pulmonary tuberculosis	21	—	—	1	2	1	4	5	2	2	1	—	2	1
Coronary disease†	503	—	—	11	19	31	63	82	81	71	65	38	26	16
Peptic ulcer	15	—	—	—	—	2	2	2	4	2	1	2	—	—
Cirrhosis of the liver and alcoholism	21	—	—	2	2	2	4	6	3	1	—	1	—	—
Unrelated causes,‡ total	945	10	19	33	36	44	86	86	112	111	114	107	117	70
Cancer of the bladder	12	—	—	—	—	1	—	—	2	2	—	5	2	—
Cancer of the stomach	31	—	—	1	—	3	2	2	8	1	6	3	4	1
Cancer of the bowel and rectum	45	1	—	3	1	1	6	4	5	13	5	3	2	1
Cancer of the prostate	15	—	—	—	—	—	—	2	1	1	3	4	4	—
Cancer, other primary site	82	4	3	4	5	3	9	7	15	10	11	7	3	1
Cancer, primary site unknown	6	—	—	—	—	1	—	—	3	—	—	1	1	—
Other respiratory disease	49	—	—	2	—	1	7	5	3	1	8	10	8	4
Cerebrovascular accidents †	136	—	—	3	3	2	6	10	7	19	27	26	22	11
Myocardial degeneration	92	—	—	2	—	1	2	2	6	6	8	11	27	27
Hypertension†	140	—	—	1	5	5	20	26	28	22	15	9	7	2
Other heart disease	39	—	1	—	—	6	2	1	3	5	9	4	5	3
Other cardiovascular disease	50	1	1	—	—	—	1	4	9	12	4	4	11	3
Nephritis	18	—	1	1	—	2	3	—	3	2	—	2	1	3
Other digestive disease	33	—	—	—	4	1	4	6	—	2	3	5	6	2
Violence	105	4	11	10	16	12	16	11	6	6	4	2	4	3
All other causes	92	—	2	6	2	5	8	6	13	9	11	11	10	9

See footnotes at end of Appendix table 1.

APPENDIX TABLE 1.—Number of person-years at risk, by age, and number of deaths, by age and cause, according to selected smoking habit characteristics. British doctors, males, 1951–61—Continued

	All ages	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85 and over
	MALE MIXED SMOKERS STOPPED†§													
Number of person-years at risk	10, 950	130	505	952	1, 160	1, 193	1, 255	1, 240	1, 178	1, 127	915	670	398	227
Number of deaths:														
All causes	306	—	—	4	2	3	12	18	25	27	52	71	49	43
Related causes,* total	124	—	—	1	1	—	3	9	11	13	27	29	17	13
Cancer of the lung	6	—	—	1	1	—	1	1	—	—	2	—	—	—
Cancer of the upper respiratory and digestive tracts	4	—	—	—	—	—	—	—	—	—	—	2	2	—
Chronic bronchitis	12	—	—	—	—	—	—	—	2	1	2	5	2	—
Pulmonary tuberculosis	3	—	—	—	—	—	—	—	1	—	1	1	—	—
Coronary disease†	97	—	—	—	—	—	2	7	8	12	22	21	13	12
Peptic ulcer	1	—	—	—	—	—	—	—	—	—	—	—	—	1
Cirrhosis of the liver and alcoholism	1	—	—	—	—	—	—	1	—	—	—	—	—	—
Unrelated causes,‡ total	182	—	—	3	1	3	9	9	14	14	25	42	32	30
Cancer of the bladder	2	—	—	—	—	—	—	—	—	—	1	—	1	—
Cancer of the stomach	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cancer of the bowel and rectum	11	—	—	—	—	1	—	—	2	—	3	3	—	2
Cancer of the prostate	5	—	—	—	—	1	—	—	—	1	1	1	1	—
Cancer, other primary site	6	—	—	—	—	—	1	1	—	—	—	2	1	1
Cancer, primary site unknown	1	—	—	—	—	—	—	—	—	—	1	—	—	—
Other respiratory disease	13	—	—	—	—	1	1	1	—	—	3	2	3	2
Cerebrovascular accidents†	37	—	—	—	—	—	—	2	5	2	5	10	9	4
Myocardial degeneration	26	—	—	—	—	—	—	1	1	—	1	8	4	11
Hypertension†	27	—	—	—	—	—	2	2	2	6	6	3	3	3
Other heart disease	9	—	—	—	1	—	—	—	1	2	1	1	2	1
Other cardiovascular disease	8	—	—	—	—	—	—	1	—	1	1	2	1	2
Nephritis	3	—	—	—	—	—	2	—	—	—	—	1	—	—
Other digestive disease	7	—	—	—	—	—	1	—	1	—	1	2	2	—
Violence	11	—	—	2	—	—	1	1	—	2	1	2	1	1
All other causes	16	—	—	1	—	—	1	—	2	—	—	5	4	3

	MALE MIXED SMOKERS CONTINUING †§													
Number of person-years at risk	46, 557	1, 525	3, 902	5, 628	5, 890	5, 355	5, 322	5, 238	4, 357	3, 525	2, 735	1, 765	932	383
Number of deaths:														
All causes	760	—	3	10	9	20	49	61	70	114	112	121	116	75
Related causes,* total	305	—	—	1	1	7	17	31	42	50	52	52	36	16
Cancer of the lung	35	—	—	—	—	—	1	5	5	5	5	7	5	2
Cancer of the upper respiratory and digestive tracts	18	—	—	—	—	—	2	1	5	5	1	—	2	2
Chronic bronchitis	16	—	—	—	—	—	—	1	3	—	3	5	2	2
Pulmonary tuberculosis	6	—	—	—	—	—	—	—	—	2	2	2	—	—
Coronary disease†	215	—	—	—	1	7	13	19	27	37	37	38	27	9
Peptic ulcer	8	—	—	—	—	—	1	1	1	—	4	—	—	1
Cirrhosis of the liver and alcoholism	7	—	—	1	—	—	—	4	1	1	—	—	—	—
Unrelated causes,‡ total	455	—	3	9	8	13	32	30	28	64	58	69	80	59
Cancer of the bladder	6	—	—	—	—	—	1	1	1	2	—	—	1	—
Cancer of the stomach	11	—	—	—	—	—	2	2	1	1	1	3	1	—
Cancer of the bowel and rectum	24	—	—	—	1	—	2	2	5	5	2	3	3	1
Cancer of the prostate	8	—	—	—	—	—	—	—	—	—	2	2	3	1
Cancer, other primary site	34	—	—	—	3	1	2	2	—	12	8	6	—	—
Cancer, primary site unknown	6	—	—	—	1	—	—	—	—	—	2	2	1	—
Other respiratory disease	28	—	—	—	—	—	1	2	1	3	4	2	6	9
Cerebrovascular accidents†	69	—	—	—	—	2	3	2	6	7	9	18	13	9
Myocardial degeneration	61	—	—	—	—	—	—	—	1	2	7	8	22	21
Hypertension†	63	—	—	—	—	3	10	9	4	11	9	8	7	2
Other heart disease	27	—	—	—	—	—	—	4	1	5	5	4	5	3
Other cardiovascular disease	24	—	—	—	—	—	—	2	2	6	3	3	3	5
Nephritis	7	—	—	—	—	—	1	—	—	2	—	1	1	2
Other digestive disease	9	—	—	—	—	—	1	1	—	2	1	2	1	1
Violence	33	—	1	7	1	5	8	2	2	2	2	1	2	—
All other causes	45	—	2	2	2	2	1	1	4	4	5	6	11	5

See footnotes at end of Appendix table 1.

APPENDIX TABLE 1.—Number of person-years at risk, by age, and number of deaths, by age and cause, according to selected smoking habit characteristics. British doctors, males, 1951–61—Continued

	All ages	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85 and over
	MALE PIPE AND CIGAR SMOKERS STOPPED†													
Number of person-years at risk	6, 410	123	389	626	661	630	640	622	558	542	562	467	371	219
Number of deaths:														
All causes	199	—	1	3	2	4	4	3	9	13	18	45	43	54
Related causes,* total	52	—	—	—	—	1	2	—	3	10	6	13	12	5
Cancer of the lung	3	—	—	—	—	—	—	—	—	2	—	—	—	1
Cancer of the upper respiratory and digestive tracts	3	—	—	—	—	—	—	—	1	—	—	1	1	—
Chronic bronchitis	3	—	—	—	—	—	—	—	—	—	—	1	2	—
Pulmonary tuberculosis	1	—	—	—	—	—	1	—	—	—	—	—	—	—
Coronary disease†	41	—	—	—	—	1	1	—	2	8	6	11	8	4
Peptic ulcer	1	—	—	—	—	—	—	—	—	—	—	—	1	—
Cirrhosis of the liver and alcoholism	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Unrelated causes,‡ total	147	—	1	3	2	3	2	3	6	3	12	32	31	49
Cancer of the bladder	1	—	—	—	—	—	—	—	—	—	—	—	1	—
Cancer of the stomach	2	—	—	—	—	—	—	1	—	—	—	—	1	—
Cancer of the bowel and rectum	5	—	—	—	—	—	—	—	1	—	—	—	—	4
Cancer of the prostate	8	—	—	—	—	—	—	—	—	—	1	1	3	3
Cancer, other primary site	7	—	—	—	—	2	1	—	1	—	—	1	1	1
Cancer, primary site unknown	1	—	—	—	—	—	—	—	—	—	1	—	—	—
Other respiratory disease	10	—	1	—	—	—	—	—	—	—	—	3	2	4
Cerebrovascular accidents†	29	—	—	—	—	—	—	1	1	—	5	9	6	7
Myocardial degeneration	26	—	—	—	—	—	—	—	—	—	—	5	6	15
Hypertension†	11	—	—	1	1	—	—	1	—	1	1	4	—	2
Other heart disease	11	—	—	—	1	—	—	—	—	—	1	3	2	4
Other cardiovascular disease	6	—	—	—	—	—	1	—	1	—	1	—	2	1
Nephritis	5	—	—	—	—	—	—	—	—	1	—	—	2	2
Other digestive disease	4	—	—	—	—	—	—	—	—	—	—	—	1	3
Violence	3	—	—	1	—	—	—	—	1	—	—	1	—	—
All other causes	18	—	—	1	—	1	—	—	1	1	2	5	4	3

	MALE PIPE AND CIGAR SMOKERS CONTINUING†													
Number of person-years at risk	32, 798	1, 160	2, 888	4, 067	4, 112	3, 585	3, 255	2, 998	2, 535	2, 305	2, 088	1, 800	1, 282	723
Number of deaths:														
All causes	650	1	5	3	8	9	20	36	38	42	88	129	132	139
Related causes,* total	216	—	—	2	2	4	6	17	17	22	42	48	38	18
Cancer of the lung	21	—	—	—	—	—	—	4	4	3	4	3	2	1
Cancer of the upper respiratory and digestive tracts	8	—	—	—	—	1	—	1	—	—	—	4	2	—
Chronic bronchitis	9	—	—	—	—	—	—	1	—	1	1	—	3	3
Pulmonary tuberculosis	4	—	—	1	—	—	—	1	—	—	1	1	—	—
Coronary disease†	162	—	—	1	2	3	6	10	12	17	36	36	27	12
Peptic ulcer	9	—	—	—	—	—	—	—	—	—	—	3	4	2
Cirrhosis of the liver and alcoholism	3	—	—	—	—	—	—	—	1	1	—	1	—	—
Unrelated causes,‡ total	434	1	5	1	6	5	14	19	21	20	46	81	94	121
Cancer of the bladder	5	—	—	—	—	—	—	—	—	—	1	3	—	1
Cancer of the stomach	18	—	—	—	—	—	—	1	—	2	7	3	3	2
Cancer of the bowel and rectum	23	—	1	—	—	1	2	1	4	1	—	1	6	6
Cancer of the prostate	13	—	—	—	—	—	1	—	—	—	3	1	7	1
Cancer, other primary site	17	—	1	—	2	—	2	2	3	—	3	3	1	—
Cancer, primary site unknown	7	—	—	—	—	—	1	1	—	2	2	—	1	—
Other respiratory disease	31	—	—	—	—	—	—	—	—	1	2	5	12	11
Cerebrovascular accidents†	84	—	—	—	—	—	2	3	2	5	11	18	22	21
Myocardial degeneration	70	—	—	—	—	—	—	—	—	1	4	18	16	31
Hypertension†	42	—	—	—	—	1	1	3	6	4	3	13	1	10
Other heart disease	15	—	—	—	—	1	1	—	—	—	1	2	4	6
Other cardiovascular disease	19	—	—	—	—	—	2	—	—	2	1	4	3	7
Nephritis	3	—	—	—	—	—	—	1	—	—	2	—	—	—
Other digestive disease	17	—	—	—	1	—	—	1	—	1	1	6	2	5
Violence	32	—	1	1	2	2	2	3	3	—	3	1	6	8
All other causes	38	1	2	—	1	—	—	3	3	1	2	3	10	12

See footnotes at end of Appendix table 1.

781-871—65——16

APPENDIX TABLE 1.—Number of person-years at risk, by age, and number of deaths, by age and cause, according to selected smoking habit characteristics. British doctors, males, 1951–61—Continued

	All ages	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85 and over
	MALES CONTINUING TO SMOKE 1–14 g/DAY†													
Number of person-years at risk	88, 513	4, 808	11, 062	13, 938	12, 570	9, 892	8, 237	7, 188	5, 637	4, 553	4, 045	3, 307	2, 157	1, 119
Number of deaths:														
All causes	1, 355	6	9	16	28	32	59	77	112	135	175	235	246	225
Related causes,* total	468	—	—	4	7	11	20	37	54	62	81	90	67	35
Cancer of the lung	43	—	—	—	1	1	2	3	5	5	11	7	5	3
Cancer of the upper respiratory and digestive tracts	13	—	—	—	—	—	—	—	2	2	—	4	4	1
Chronic bronchitis	27	—	—	—	—	—	—	1	2	1	4	9	5	5
Pulmonary tuberculosis	11	—	—	1	—	—	—	2	—	2	2	2	1	1
Coronary disease †	357	—	—	3	6	10	17	30	43	51	63	63	49	22
Peptic ulcer	11	—	—	—	—	—	—	—	—	—	1	4	3	3
Cirrhosis of the liver and alcoholism	6	—	—	—	—	—	1	1	2	1	—	1	—	—
Unrelated causes, ‡ total	887	6	9	12	21	21	39	40	58	73	94	145	179	190
Cancer of the bladder	11	—	—	—	—	—	—	—	1	1	1	5	2	1
Cancer of the stomach	28	—	—	1	—	—	—	3	3	1	8	5	5	2
Cancer of the bowel and rectum	45	1	1	—	—	—	3	3	9	6	4	5	6	7
Cancer of the prostate	19	—	—	—	—	—	—	—	—	1	3	4	9	2
Cancer, other primary site	52	3	2	—	6	2	4	3	4	7	9	8	3	1
Cancer, primary site unknown	10	—	—	—	1	1	—	—	2	2	1	1	2	—
Other respiratory disease	60	—	—	—	—	—	3	2	—	2	8	9	17	19
Cerebrovascular accidents †	143	—	—	—	1	1	4	5	7	13	15	35	34	28
Myocardial degeneration	129	—	—	—	—	—	—	1	1	3	7	24	38	55
Hypertension †	98	—	—	—	1	1	7	11	14	17	12	16	8	11
Other heart disease	40	—	—	—	—	1	1	1	2	5	6	3	9	12
Other cardiovascular disease	40	—	1	—	—	—	1	1	1	5	1	8	11	11
Nephritis	13	—	—	1	—	1	1	1	—	2	2	2	1	2
Other digestive disease	24	—	—	—	1	1	2	—	—	1	—	6	6	7
Violence	80	1	3	6	9	10	10	5	3	4	7	2	10	10
All other causes	95	1	2	4	2	3	3	4	11	3	10	12	18	22

	MALES CONTINUING TO SMOKE 15–24 g/DAY†													
Number of person-years at risk	84, 222	3, 810	9, 530	13, 082	13, 040	10, 965	9, 453	8, 245	5, 872	4, 075	3, 013	1, 888	907	342
Number of deaths:														
All causes	1, 071	4	12	27	22	44	100	115	130	130	151	143	122	71
Related causes,* total	470	—	—	6	8	27	53	61	75	60	72	53	33	22
Cancer of the lung	68	—	—	—	—	2	7	9	16	10	10	9	4	1
Cancer of the upper respiratory and digestive tracts	13	—	—	—	—	1	2	2	3	3	1	—	—	1
Chronic bronchitis	30	—	—	—	—	—	—	3	6	4	6	3	3	5
Pulmonary tuberculosis	9	—	—	1	—	—	1	2	1	2	1	—	1	—
Coronary disease†	332	—	—	3	8	21	42	42	45	40	52	40	24	15
Peptic ulcer	11	—	—	—	—	2	1	2	2	—	2	1	1	—
Cirrhosis of the liver and alcoholism	7	—	—	2	—	1	—	1	2	1	—	—	—	—
Unrelated causes,‡ total	601	4	12	21	14	17	47	54	55	70	79	90	89	49
Cancer of the bladder	7	—	—	—	—	—	1	1	—	1	—	3	1	—
Cancer of the stomach	21	—	—	—	—	2	2	2	3	2	3	4	2	1
Cancer of the bowel and rectum	23	—	—	3	—	2	5	1	4	4	—	1	2	1
Cancer of the prostate	13	—	—	—	—	—	1	1	1	—	3	3	4	—
Cancer, other primary site	45	1	2	3	2	2	5	3	5	10	6	5	1	—
Cancer, primary site unknown	6	—	—	—	—	—	1	—	—	—	2	2	1	—
Other respiratory disease	33	—	—	1	—	—	1	4	2	2	3	8	8	4
Cerebrovascular accidents†	95	—	—	2	2	2	4	4	5	14	18	18	17	9
Myocardial degeneration	71	—	—	2	—	—	—	—	4	3	8	12	22	20
Hypertension†	90	—	—	1	—	3	11	17	12	13	12	13	6	2
Other heart disease	30	—	1	—	—	2	2	2	2	4	9	4	4	—
Other cardiovascular disease	32	1	—	—	—	—	1	1	6	8	4	3	5	3
Nephritis	8	—	—	—	—	—	1	—	1	2	—	—	1	3
Other digestive disease	27	—	—	—	3	—	3	6	—	1	5	6	2	1
Violence	46	2	6	5	6	3	6	8	4	—	1	2	2	1
All other causes	54	—	3	4	1	1	3	4	6	6	5	6	11	4

See footnotes at end of Appendix table 1.

APPENDIX TABLE 1.—Number of person-years at risk, by age, and number of deaths, by age and cause, according to selected smoking habit characteristics. British doctors, males, 1951–61—Continued

	All ages	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85 and over
	MALES CONTINUING TO SMOKE 25 OR MORE g/DAY†													
Number of person-years at risk	42, 888	760	2, 578	4, 892	6, 410	6, 810	6, 805	5, 918	3, 955	2, 397	1, 373	637	275	78
Number of deaths:														
All causes	691	1	6	17	28	39	88	113	107	109	87	48	36	12
Related causes,* total	345	—	—	7	13	15	42	72	59	57	40	26	13	1
Cancer of the lung	74	—	—	—	1	2	7	18	16	11	7	7	5	—
Cancer of the upper respiratory and digestive tracts	20	—	—	—	—	—	2	3	4	7	1	2	—	1
Chronic bronchitis	21	—	—	—	—	1	2	1	2	2	6	6	1	—
Pulmonary tuberculosis	11	—	—	—	2	1	3	2	1	—	1	1	—	—
Coronary disease†	191	—	—	6	8	10	23	39	32	34	23	9	7	—
Peptic ulcer	10	—	—	—	—	—	2	1	3	2	2	—	—	—
Cirrhosis of the liver and alcoholism	18	—	—	1	2	1	3	8	1	1	—	1	—	—
Unrelated causes,‡ total	346	1	6	10	15	24	46	41	48	52	47	22	23	11
Cancer of the bladder	5	—	—	—	—	1	—	—	2	2	—	—	—	—
Cancer of the stomach	11	—	—	—	—	1	2	—	3	1	3	—	1	—
Cancer of the bowel and rectum	24	—	—	—	2	—	2	3	1	9	3	1	3	—
Cancer of the prostate	4	—	—	—	—	—	—	1	—	—	2	—	1	—
Cancer, other primary site	36	—	—	1	2	—	4	5	9	5	7	3	—	—
Cancer, primary site unknown	3	—	—	—	—	—	—	1	1	—	1	—	—	—
Other respiratory disease	15	—	—	1	—	1	4	1	2	1	3	—	1	1
Cerebrovascular accidents†	51	—	—	1	—	1	3	6	3	4	14	9	6	4
Myocardial degeneration	23	—	—	—	—	1	2	1	2	3	4	1	5	4
Hypertension†	57	—	—	—	4	5	13	10	12	7	3	1	1	1
Other heart disease	11	—	—	—	—	4	—	2	—	1	—	3	1	—
Other cardiovascular disease	21	—	—	—	—	—	1	4	4	7	3	—	1	1
Nephritis	7	—	1	—	—	1	2	—	2	—	—	1	—	—
Other digestive disease	8	—	—	—	1	—	—	2	—	3	—	1	1	—
Violence	44	1	4	7	4	6	10	3	4	4	1	—	—	—
All other causes	26	—	1	—	2	3	3	2	3	5	3	2	2	—

	MALES CONTINUING TO SMOKE 1–14 CIGARETTES/DAY†													
Number of person-years at risk	45, 283	2, 853	6, 420	7, 755	6, 750	5, 257	4, 353	3, 718	2, 597	1, 767	1, 578	1, 217	715	303
Number of deaths:														
All causes	589	5	4	9	16	20	30	38	66	65	81	98	89	68
Related causes,* total	216	—	—	3	4	8	12	18	31	30	39	36	22	13
Cancer of the lung	22	—	—	—	1	1	2	1	2	3	6	5	1	—
Cancer of the upper respiratory and digestive tracts	2	—	—	—	—	—	—	—	—	—	—	1	—	1
Chronic bronchitis	14	—	—	—	—	—	—	—	1	1	3	6	2	1
Pulmonary tuberculosis	4	—	—	—	—	—	—	1	—	1	—	—	1	1
Coronary disease†	171	—	—	3	3	7	9	16	27	25	30	23	18	10
Peptic ulcer	1	—	—	—	—	—	—	—	—	—	—	1	—	—
Cirrhosis of the liver and alcoholism	2	—	—	—	—	—	1	—	1	—	—	—	—	—
Unrelated causes,‡ total	373	5	4	6	12	12	18	20	35	35	42	62	67	55
Cancer of the bladder	6	—	—	—	—	—	—	—	1	—	—	4	1	—
Cancer of the stomach	11	—	—	1	—	—	—	1	3	—	2	2	2	—
Cancer of the bowel and rectum	17	1	—	—	—	—	2	1	4	3	3	2	—	1
Cancer of the prostate	4	—	—	—	—	—	—	—	—	1	1	1	1	—
Cancer, other primary site	29	3	1	—	2	2	1	2	2	5	3	5	2	1
Cancer, primary site unknown	4	—	—	—	—	1	—	—	2	—	—	1	—	—
Other respiratory disease	17	—	—	—	—	—	3	—	—	—	4	4	4	2
Cerebrovascular accidents†	60	—	—	—	1	—	3	3	3	8	8	13	12	9
Myocardial degeneration	49	—	—	—	—	—	—	1	1	1	3	7	15	21
Hypertension†	46	—	—	—	1	—	1	5	10	9	8	5	5	2
Other heart disease	13	—	—	—	—	1	—	—	1	1	3	2	2	3
Other cardiovascular disease	18	—	1	—	—	—	—	1	—	1	—	4	8	3
Nephritis	7	—	—	1	—	1	1	—	—	1	—	1	1	1
Other digestive disease	12	—	—	—	1	1	1	—	—	—	—	3	4	2
Violence	37	1	2	1	7	4	4	3	1	3	3	1	4	3
All other causes	43	—	—	3	—	2	2	3	7	2	4	7	6	7

See footnotes at end of Appendix table 1.

APPENDIX TABLE 1.—Number of person-years at risk, by age, and number of deaths, by age and cause, according to selected smoking habit characteristics. British doctors, males, 1951–61—Continued

	All ages	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85 and over
	MALES CONTINUING TO SMOKE 15–24 CIGARETTES/DAY†													
Number of person-years at risk	58, 913	3, 212	7, 828	10, 395	9, 998	8, 012	6, 395	5, 235	3, 440	2, 033	1, 265	705	293	102
Number of deaths:														
All causes	601	4	10	23	18	31	75	84	87	80	72	49	46	22
Related causes,* total	283	—	—	4	8	20	43	49	52	35	35	16	10	11
Cancer of the lung	51	—	—	—	—	2	7	7	13	7	8	4	2	1
Cancer of the upper respiratory and digestive tracts	7	—	—	—	—	—	1	1	1	3	1	—	—	—
Chronic bronchitis	21	—	—	—	—	—	—	3	5	3	3	2	1	4
Pulmonary tuberculosis	7	—	—	1	—	—	1	2	1	1	—	—	1	—
Coronary disease†	184	—	—	2	8	15	34	33	28	21	22	9	6	6
Peptic ulcer	8	—	—	—	—	2	—	2	2	—	1	1	—	—
Cirrhosis of the liver and alcoholism	5	—	—	1	—	1	—	1	2	—	—	—	—	—
Unrelated causes,‡ total	318	4	10	19	10	11	32	35	35	45	37	33	36	11
Cancer of the bladder	3	—	—	—	—	—	—	—	—	1	—	1	1	—
Cancer of the stomach	12	—	—	—	—	2	1	1	2	1	2	1	1	1
Cancer of the bowel and rectum	9	—	—	3	—	1	2	—	—	3	—	—	—	—
Cancer of the prostate	7	—	—	—	—	—	—	1	1	—	—	3	2	—
Cancer, other primary site	28	1	2	3	1	1	4	2	4	4	4	1	1	—
Cancer, primary site unknown	1	—	—	—	—	—	—	—	—	—	—	—	1	—
Other respiratory disease	21	—	—	1	—	—	1	4	2	—	2	6	4	1
Cerebrovascular accidents†	45	—	—	2	2	1	1	2	3	10	8	8	7	1
Myocardial degeneration	26	—	—	2	—	—	—	—	3	3	2	4	8	4
Hypertension†	50	—	—	1	—	1	9	12	7	9	5	4	2	—
Other heart disease	21	—	1	—	—	2	2	1	2	3	6	1	3	—
Other cardiovascular disease	17	1	—	—	—	—	1	—	6	6	1	—	2	—
Nephritis	4	—	—	—	—	—	—	—	1	1	—	—	—	2
Other digestive disease	14	—	—	—	2	—	3	4	—	—	3	1	1	—
Violence	33	2	6	4	5	3	5	6	1	—	—	1	—	—
All other causes	27	—	1	3	—	—	3	2	3	4	4	2	3	2

		MALES CONTINUING TO SMOKE 25 OR MORE CIGARETTES/DAY†												
Number of person-years at risk	32, 072	628	2, 132	4, 067	5, 270	5, 458	5, 170	4, 162	2, 535	1, 395	765	345	117	28
Number of deaths:														
All causes	517	1	5	15	27	35	73	86	88	73	60	29	21	4
Related causes,* total	263	—	—	7	13	14	37	55	46	42	25	17	7	—
Cancer of the lung	56	—	—	—	1	2	6	13	13	8	5	4	4	—
Cancer of the upper respiratory and digestive tracts	11	—	—	—	—	—	1	2	3	4	—	1	—	—
Chronic bronchitis	18	—	—	—	—	1	2	—	1	2	6	5	1	—
Pulmonary tuberculosis	10	—	—	—	2	1	3	2	1	—	1	—	—	—
Coronary disease†	148	—	—	6	8	9	20	33	26	25	13	6	2	—
Peptic ulcer	6	—	—	—	—	—	2	—	2	2	—	—	—	—
Cirrhosis of the liver and alcoholism	14	—	—	1	2	1	3	5	—	1	—	1	—	—
Unrelated causes,‡ total	254	1	5	8	14	21	36	31	42	31	35	12	14	4
Cancer of the bladder	3	—	—	—	—	1	—	—	1	1	—	—	—	—
Cancer of the stomach	8	—	—	—	—	1	1	—	3	—	2	—	1	—
Cancer of the bowel and rectum	19	—	—	—	1	—	2	3	1	7	2	1	2	—
Cancer of the prostate	4	—	—	—	—	—	—	1	—	—	2	—	1	—
Cancer, other primary site	25	—	—	1	2	—	4	3	9	1	4	1	—	—
Cancer, primary site unknown	1	—	—	—	—	—	—	—	1	—	—	—	—	—
Other respiratory disease	11	—	—	1	—	1	3	1	1	1	2	—	—	1
Cerebrovascular accidents†	31	—	—	1	—	1	2	5	1	1	11	5	3	1
Myocardial degeneration	17	—	—	—	—	1	2	1	2	2	3	—	4	2
Hypertension†	44	—	—	—	4	4	10	9	11	4	2	—	—	—
Other heart disease	5	—	—	—	—	3	—	—	—	1	—	1	—	—
Other cardiovascular disease	15	—	—	—	—	—	—	3	3	5	3	—	1	—
Nephritis	7	—	1	—	—	1	2	—	2	—	—	1	—	—
Other digestive disease	7	—	—	—	1	—	—	2	—	2	—	1	1	—
Violence	35	1	3	5	4	5	7	2	4	3	1	—	—	—
All other causes	22	—	1	—	2	3	3	1	3	3	3	2	1	—

See footnotes at end of Appendix table 1.

APPENDIX TABLE 1.—Number of person-years at risk, by age, and number of deaths, by age and cause, according to selected smoking habit characteristics. British doctors, males, 1951–61—Continued

	All ages	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85 and over
	MALE PIPE AND CIGAR SMOKERS CONTINUING TO SMOKE 1–14 g/day†													
Number of person-years at risk	23, 585	1, 075	2, 538	3, 342	3, 117	2, 490	2, 060	1, 813	1, 565	1, 457	1, 350	1, 223	962	593
Number of deaths:														
All causes	462	1	3	2	7	5	13	21	25	29	56	85	98	117
Related causes,* total	144	—	—	1	2	2	4	11	11	13	25	33	29	13
Cancer of the lung	12	—	—	—	—	—	—	2	3	1	2	1	2	1
Cancer of the upper respiratory and digestive tracts	5	—	—	—	—	—	—	—	—	—	—	3	2	—
Chronic bronchitis	7	—	—	—	—	—	—	1	—	—	1	—	2	3
Pulmonary tuberculosis	4	—	—	1	—	—	—	1	—	—	1	1	—	—
Coronary disease†	105	—	—	—	2	2	4	7	7	11	21	24	20	7
Peptic ulcer	8	—	—	—	—	—	—	—	—	—	—	3	3	2
Cirrhosis of the liver and alcoholism	3	—	—	—	—	—	—	—	1	1	—	1	—	—
Unrelated causes,‡ total	318	1	3	1	5	3	9	10	14	16	31	52	69	104
Cancer of the bladder	3	—	—	—	—	—	—	—	—	—	1	1	—	1
Cancer of the stomach	14	—	—	—	—	—	—	1	—	1	5	2	3	2
Cancer of the bowel and rectum	15	—	1	—	—	—	1	—	3	1	—	1	3	5
Cancer of the prostate	11	—	—	—	—	—	—	—	—	—	2	1	7	1
Cancer, other primary site	13	—	1	—	2	—	2	1	2	—	3	1	1	—
Cancer, primary site unknown	4	—	—	—	—	—	—	—	—	2	1	—	1	—
Other respiratory disease	26	—	—	—	—	—	—	—	—	—	2	4	9	11
Cerebrovascular accidents†	58	—	—	—	—	—	1	2	2	4	5	14	15	15
Myocardial degeneration	52	—	—	—	—	—	—	—	—	1	2	12	11	26
Hypertension†	28	—	—	—	—	1	1	2	3	3	2	7	1	8
Other heart disease	10	—	—	—	—	—	1	—	—	—	1	—	2	6
Other cardiovascular disease	15	—	—	—	—	—	1	—	—	2	1	2	3	6
Nephritis	3	—	—	—	—	—	—	1	—	—	2	—	—	—
Other digestive disease	11	—	—	—	—	—	—	—	—	1	—	3	2	5
Violence	27	—	1	1	2	2	2	2	2	—	2	1	5	7
All other causes	28	1	—	—	1	—	—	1	2	1	2	3	6	11

	MALE PIPE AND CIGAR SMOKERS CONTINUING TO SMOKE 15–24 g/DAY†													
Number of person-years at risk	7, 594	78	318	640	867	938	957	913	745	655	598	505	272	108
Number of deaths:														
All causes	162	—	2	1	1	3	6	10	13	10	27	39	31	19
Related causes,* total	63	—	—	1	—	2	2	4	6	7	14	13	9	5
Cancer of the lung	6	—	—	—	—	—	—	—	1	1	2	2	—	—
Cancer of the upper respiratory and digestive tracts	2	—	—	—	—	1	—	1	—	—	—	—	—	—
Chronic bronchitis	2	—	—	—	—	—	—	—	—	1	—	—	1	—
Pulmonary tuberculosis	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Coronary disease†	52	—	—	1	—	1	2	3	5	5	12	11	7	5
Peptic ulcer	1	—	—	—	—	—	—	—	—	—	—	—	1	—
Cirrhosis of the liver and alcoholism	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Unrelated causes,‡ total	99	—	2	—	1	1	4	6	7	3	13	26	22	14
Cancer of the bladder	2	—	—	—	—	—	—	—	—	—	—	2	—	—
Cancer of the stomach	2	—	—	—	—	—	—	—	—	—	1	1	—	—
Cancer of the bowel and rectum	7	—	—	—	—	1	1	1	1	—	—	—	2	1
Cancer of the prostate	2	—	—	—	—	—	1	—	—	—	1	—	—	—
Cancer, other primary site	2	—	—	—	—	—	—	—	1	—	—	1	—	—
Cancer, primary site unknown	2	—	—	—	—	—	1	—	—	—	1	—	—	—
Other respiratory disease	5	—	—	—	—	—	—	—	—	1	—	1	3	—
Cerebrovascular accidents†	24	—	—	—	—	—	1	1	—	1	6	4	6	5
Myocardial degeneration	16	—	—	—	—	—	—	—	—	—	2	5	5	4
Hypertension†	12	—	—	—	—	—	—	1	3	1	—	6	—	1
Other heart disease	2	—	—	—	—	—	—	—	—	—	—	1	1	—
Other cardiovascular disease	3	—	—	—	—	—	—	—	—	—	—	2	—	1
Nephritis	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Other digestive disease	6	—	—	—	1	—	—	1	—	—	1	3	—	—
Violence	5	—	—	—	—	—	—	1	1	—	1	—	1	1
All other causes	9	—	2	—	—	—	—	1	1	—	—	—	4	1

See footnotes at end of Appendix table 1.

Appendix table 1.—Number of person-years at risk, by age, and number of deaths, by age and cause, according to selected smoking habit characteristics. British doctors, males, 1951–61—Continued

	All ages	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85 and over
	MALE PIPE AND CIGAR SMOKERS CONTINUING TO SMOKE 25 OR MORE g/DAY†													
Number of person-years at risk	1,620	7	32	85	128	157	238	272	225	193	140	72	48	22
Number of deaths:														
All causes	26	—	—	—	—	1	1	5	—	3	5	5	3	3
Related causes,* total	9	—	—	—	—	—	—	2	—	2	3	2	—	—
Cancer of the lung	3	—	—	—	—	—	—	2	—	1	—	—	—	—
Cancer of the upper respiratory and digestive tracts	1	—	—	—	—	—	—	—	—	—	—	1	—	—
Chronic bronchitis	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pulmonary tuberculosis	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Coronary disease†	5	—	—	—	—	—	—	—	—	1	3	1	—	—
Peptic ulcer	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cirrhosis of the liver and alcoholism	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Unrelated causes,‡ total	17	—	—	—	—	1	1	3	—	1	2	3	3	3
Cancer of the bladder	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cancer of the stomach	2	—	—	—	—	—	—	—	—	1	1	—	—	—
Cancer of the bowel and rectum	1	—	—	—	—	—	—	—	—	—	—	—	1	—
Cancer of the prostate	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cancer, other primary site	2	—	—	—	—	—	—	1	—	—	—	1	—	—
Cancer, primary site unknown	1	—	—	—	—	—	—	1	—	—	—	—	—	—
Other respiratory disease	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cerebrovascular accidents†	2	—	—	—	—	—	—	—	—	—	—	—	1	1
Myocardial degeneration	2	—	—	—	—	—	—	—	—	—	—	1	—	1
Hypertension†	2	—	—	—	—	—	—	—	—	—	1	—	—	1
Other heart disease	3	—	—	—	—	1	—	—	—	—	—	1	1	—
Other cardiovascular disease	1	—	—	—	—	—	1	—	—	—	—	—	—	—
Nephritis	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Other digestive disease	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Violence	—	—	—	—	—	—	—	—	—	—	—	—	—	—
All other causes	1	—	—	—	—	—	—	1	—	—	—	—	—	—

	MALE CIGAR SMOKERS†													
Number of person-years at risk	1,133	5	13	40	112	172	168	130	105	110	108	90	55	25
Number of deaths from all causes	29	—	—	—	—	—	—	2	2	1	4	4	12	4

* Diseases for which association with smoking was revealed.
† NOTE: *See* pages 216 and 217 for definitions of disease categories and smoking habits.
‡ Diseases for which no association with smoking was revealed.
§ Smokers of cigarettes and of pipes or cigars.

APPENDIX TABLE 2.—Mortality in first and second halves of study of British doctors, males (1951–56 and 1956–61)*

A. Number of person-years at risk by age and smoking habits

Period and smoking habits†	All ages	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85 and over
1951–56:														
Total males	164, 725	13, 155	23, 010	24, 778	22, 102	18, 215	17, 510	13, 950	9, 695	7, 898	6, 117	4, 497	2, 660	1, 138
Nonsmokers	27, 403	4, 195	5, 788	4, 720	3, 620	2, 547	2, 048	1, 465	905	665	532	448	315	155
Cigarette smokers, total	86, 757	6, 398	12, 082	13, 893	12, 777	10, 537	9, 973	7, 630	4, 683	3, 422	2, 492	1, 648	890	332
Cigarette smokers stopped	16, 928	570	1, 485	2, 200	2, 310	2, 110	2, 168	1, 812	1, 315	1, 040	775	588	382	173
Cigarette smokers continuing	69, 830	5, 827	10, 598	11, 693	10, 467	8, 427	7, 805	5, 818	3, 367	2, 383	1, 717	1, 060	508	160
1–14 cigarettes/day	23, 167	2, 435	4, 000	3, 772	3, 010	2, 288	2, 132	1, 673	1, 052	893	837	610	345	120
15–24 cigarettes/day	30, 000	2, 810	5, 037	5, 403	4, 640	3, 427	3, 088	2, 340	1, 345	893	555	310	122	30
25 or more cigarettes/day	16, 662	582	1, 560	2, 518	2, 818	2, 712	2, 585	1, 805	970	597	325	140	40	10
1956–61:														
Total males	155, 460	2, 215	13, 070	22, 863	24, 550	21, 785	17, 645	16, 615	12, 787	8, 507	6, 525	4, 483	2, 825	1, 590
Nonsmokers	27, 257	943	4, 175	5, 750	4, 700	3, 585	2, 492	1, 973	1, 367	830	557	408	292	185
Cigarette smokers, total	82, 053	897	6, 350	12, 005	13, 733	12, 567	10, 170	9, 400	6, 900	3, 988	2, 760	1, 775	1, 003	505
Cigarette smokers stopped	15, 615	32	568	1, 480	2, 182	2, 268	2, 057	2, 103	1, 695	1, 175	870	567	385	233
Cigarette smokers continuing	66, 438	865	5, 782	10, 525	11, 550	10, 300	8, 112	7, 298	5, 205	2, 813	1, 890	1, 207	618	273
1–14 cigarettes/day	22, 115	418	2, 420	3, 982	3, 740	2, 970	2, 220	2, 045	1, 545	875	740	608	370	182
15–24 cigarettes/day	28, 913	402	2, 790	4, 993	5, 357	4, 585	3, 308	2, 895	2, 095	1, 140	710	395	170	73
25 or more cigarettes/day	15, 410	45	573	1, 550	2, 452	2, 745	2, 585	2, 357	1, 565	798	440	205	78	17

B. Number of deaths by age, smoking habits, and cause of death, 1951–56

	TOTAL MALES													
Number of deaths:														
All causes	2, 108	13	30	44	45	72	156	169	208	219	282	335	304	231
Cancer of the lung	99	—	—	—	1	1	8	14	15	21	19	13	4	3
Chronic bronchitis	51	—	—	—	—	1	2	4	6	2	11	12	9	4

Coronary disease†	577	—	—	8	13	34	53	60	71	67	97	86	64	24
Other related causes	69	—	—	3	1	3	8	11	13	7	8	9	5	1
Unrelated causes	1, 312	13	30	33	30	33	85	80	103	122	147	215	222	199
	MALE NONSMOKERS†													
Number of deaths:														
All causes	205	2	6	7	—	4	10	18	14	14	22	38	30	40
Cancer of the lung	1	—	—	—	—	—	—	—	—	—	—	1	—	—
Chronic bronchitis	1	—	—	—	—	—	—	—	—	—	—	—	1	—
Coronary disease†	52	—	—	1	—	3	3	9	5	3	10	7	8	3
Other related causes	1	—	—	—	—	—	—	—	—	—	1	—	—	—
Unrelated causes	150	2	6	6	—	1	7	9	9	11	11	30	21	37
	MALE CIGARETTE SMOKERS CONTINUING													
Number of deaths:														
All causes	776	10	14	26	27	43	94	80	104	99	104	71	65	39
Cancer of the lung	55	—	—	—	—	1	6	11	10	10	9	7	—	1
Chronic bronchitis	23	—	—	—	—	1	1	2	2	2	6	4	3	2
Coronary disease†	227	—	—	6	10	20	35	26	35	28	35	14	11	7
Other related causes	37	—	—	3	1	3	8	6	6	3	3	2	1	1
Unrelated causes	434	10	14	17	16	18	44	35	51	56	51	44	50	28
	MALE CIGARETTE SMOKERS STOPPED†													
Number of deaths:														
All causes	246	—	1	3	5	12	12	22	25	17	31	38	44	36
Cancer of the lung	8	—	—	—	—	—	—	—	2	3	1	1	1	—
Chronic bronchitis	9	—	—	—	—	—	1	1	1	—	3	2	1	—
Coronary disease†	65	—	—	—	1	6	2	7	9	6	8	11	8	7
Other related causes	7	—	—	—	—	—	—	3	2	1	—	1	—	—
Unrelated causes	157	—	1	3	4	6	9	11	11	7	19	23	34	29

See footnotes at end of Appendix table 2.

Appendix table 2.—Mortality in first and second halves of study of British doctors, males (1951–56 and 1956–61)*—Continued

C. Number of deaths by age, smoking habits, and cause of death, 1956–61

Period and smoking habits†	All ages	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85 and over
	TOTAL MALES													
Number of deaths:														
All causes	2, 489	1	14	42	52	89	155	238	261	287	322	348	340	340
Cancer of the lung	108	—	—	2	2	4	9	17	25	10	13	13	11	2
Chronic bronchitis	60	—	—	—	—	—	2	2	8	7	11	16	8	6
Coronary disease†	710	—	—	6	11	19	43	94	94	110	115	98	66	54
Other related causes	101	—	—	2	4	3	9	18	12	15	9	12	9	8
Unrelated causes	1, 510	1	14	32	35	63	92	107	122	145	174	209	246	270
	MALE NONSMOKERS†													
Number of deaths:														
All causes	231	1	8	7	7	12	18	22	15	22	21	27	26	45
Cancer of the lung	2	—	—	1	—	—	—	—	—	—	—	1	—	—
Chronic bronchitis	1	—	—	—	—	—	—	—	—	—	—	1	—	—
Coronary disease†	60	—	—	—	1	1	5	8	6	7	8	12	4	8
Other related causes	2	—	—	—	—	—	1	—	—	—	1	—	—	—
Unrelated causes	166	1	8	6	6	11	12	14	9	15	12	13	22	37

	MALE CIGARETTE SMOKERS CONTINUING†													
Number of deaths:														
All causes	931	—	5	21	34	43	84	128	137	119	109	105	91	55
Cancer of the lung	74	—	—	—	2	4	9	10	18	8	10	6	7	—
Chronic bronchitis	30	—	—	—	—	—	1	1	5	4	6	9	1	3
Coronary disease†	276	—	—	5	9	11	28	56	46	43	30	24	15	9
Other related causes	40	—	—	—	3	2	4	10	7	9	—	3	1	1
Unrelated causes	511	—	5	16	20	26	42	51	61	55	63	63	67	42
	MALE CIGARETTE SMOKERS STOPPED†													
Number of deaths:														
All causes	293	—	1	2	3	11	8	19	32	39	47	38	48	45
Cancer of the lung	2	—	—	—	—	—	—	—	1	—	1	—	—	—
Chronic bronchitis	7	—	—	—	—	—	1	—	1	1	1	1	2	—
Coronary disease†	92	—	—	1	—	1	1	12	15	16	20	10	9	7
Other related causes	6	—	—	—	1	—	—	1	—	—	3	—	—	1
Unrelated causes	186	—	1	1	2	10	6	6	15	22	22	27	37	37

*The investigation began on November 1, 1951, and the first half was completed on October 31, 1956.

†*See* footnote to Appendix table 1.

APPENDIX TABLE 3.—Number of person-years at risk, by age, and amount smoked for continuing cigarette smokers. British doctors, males, 1951–61

Number of cigarettes per day†	All ages	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85 and over
1–9	21, 711	1, 215	2, 913	3, 645	3, 207	2, 500	2, 095	1, 788	1, 275	925	838	682	438	190
10–14	23, 572	1, 638	3, 507	4, 110	3, 543	2, 757	2, 258	1, 930	1, 322	842	740	535	277	113
15–19	23, 713	1, 542	3, 533	4, 522	4, 038	2, 950	2, 278	1, 825	1, 245	793	497	288	150	52
20–24	35, 200	1, 670	4, 295	5, 873	5, 960	5, 062	4, 117	3, 410	2, 195	1, 240	768	417	143	50
25–34	24, 252	560	1, 837	3, 302	4, 037	3, 998	3, 723	3, 002	1, 847	1, 018	553	253	97	25
35 or more	7, 820	68	295	765	1, 233	1, 460	1, 447	1, 160	688	377	212	92	20	3

†*See* footnote to Appendix table 1.

APPENDIX TABLE 4.—Number of person-years at risk by age, smoking habits, and place of residence. British doctors, males, 1951–61

Smoking habits†	All ages	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85 and over
	CONURBATIONS													
Nonsmokers	22, 622	2, 215	4, 270	4, 350	3, 225	2, 270	1, 767	1, 473	1, 050	650	425	277	140	100
Cigarette smokers continuing:														
1–14/day	17, 308	1, 260	2, 713	3, 067	2, 458	1, 887	1, 670	1, 458	970	625	512	390	205	93
15–24/day	21, 580	1, 255	2, 968	3, 800	3, 460	2, 707	2, 293	2, 047	1, 415	813	475	232	83	32
25 or more/day	11, 195	213	737	1, 375	1, 730	1, 820	1, 883	1, 570	937	465	257	148	55	5

	LARGE TOWNS (POPULATION OVER 50,000)													
Nonsmokers	11, 230	1, 002	1, 880	2, 085	1, 815	1, 438	1, 075	702	378	257	193	170	162	73
Cigarette smokers continuing:														
1–14/day	9, 340	578	1, 280	1, 507	1, 333	1, 130	965	835	585	352	313	272	142	48
15–24/day	12, 133	687	1, 598	2, 177	2, 145	1, 733	1, 320	1, 015	635	375	258	132	43	15
25 or more/day	6, 405	135	410	793	1, 045	1, 075	1, 055	877	485	278	162	58	22	10
	SMALL TOWNS (POPULATION UNDER 50,000)													
Nonsmokers	11, 070	947	1, 833	2, 035	1, 750	1, 303	957	750	495	315	250	195	157	83
Cigarette smokers continuing:														
1–14/day	10, 238	580	1, 327	1, 708	1, 573	1, 225	980	815	585	455	440	305	190	55
15–24/day	14, 235	683	1, 710	2, 465	2, 500	1, 957	1, 593	1, 327	865	500	313	192	93	37
25 or more/day	7, 697	127	455	938	1, 312	1, 377	1, 230	993	645	347	155	80	25	13
	RURAL AREAS													
Nonsmokers	7, 925	648	1, 380	1, 502	1, 243	945	632	418	290	247	213	197	138	72
Cigarette smokers continuing:														
1–14/day	7, 001	310	825	1, 210	1, 207	887	625	492	370	300	293	232	160	90
15–24/day	9, 232	427	1, 165	1, 563	1, 630	1, 428	1, 055	757	465	303	210	137	72	20
25 or more/day	5, 418	95	353	700	922	983	860	620	393	260	162	55	15	0

†*See* footnote to Appendix table 1.

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Appendix table 5.—Number of person-years at risk, by age, and number of deaths, by age and cause, according to smoking habits (allowing for changes in smoking habits recorded in 1957 questionnaire—Method of analysis B). British doctors, males, 1951–61

	All ages	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85 and over
MALE NONSMOKERS*														
Number of person-years at risk	54, 054	4, 655	10, 328	10, 366	8, 162	5, 969	4, 496	3, 512	2, 201	1, 421	1, 121	826	621	376
Number of deaths:														
All causes	436	3	14	14	6	17	27	37	32	36	43	64	57	86
Cancer of the lung	3	—	—	1	—	—	—	—	—	—	—	2	—	—
Chronic bronchitis	2	—	—	—	—	—	—	—	—	—	—	1	1	—
Coronary disease*	113	—	—	1	1	4	8	16	12	10	18	18	14	11
Other related causes†	3	—	—	—	—	—	1	—	—	—	2	—	—	—
Unrelated causes‡	315	3	14	12	5	13	18	21	20	26	23	43	42	75
MALE CIGARETTE SMOKERS CONTINUING, 1–14/DAY*														
Number of person-years at risk	41, 800	2, 626	6, 239	7, 030	6, 043	4, 745	3, 967	3, 579	2, 350	1, 671	1, 479	1, 109	676	286
Number of deaths:														
All causes	565	5	4	10	14	20	28	38	71	61	74	92	85	63
Cancer of the lung	25	—	—	—	1	2	2	1	4	3	5	6	1	—
Chronic bronchitis	14	—	—	—	—	—	—	—	2	1	3	4	2	2
Coronary disease*	169	—	—	3	2	7	9	17	29	24	29	22	19	8
Other related causes†	11	—	—	—	—	—	1	2	2	1	—	2	1	2
Unrelated causes‡	346	5	4	7	11	11	16	18	34	32	37	58	62	51

	MALE CIGARETTE SMOKERS CONTINUING, 15–24/DAY*													
Number of person-years at risk	53, 480	3, 001	7, 581	9, 654	9, 099	6, 937	5, 652	4, 817	2, 872	1, 798	1, 146	589	246	88
Number of deaths:														
All causes	543	4	10	17	15	27	70	78	77	75	68	43	41	18
Cancer of the lung	44	—	—	—	—	—	7	6	10	6	9	3	2	1
Chronic bronchitis	19	—	—	—	—	—	1	2	3	3	4	3	—	3
Coronary disease*	168	—	—	2	8	14	31	31	23	19	20	9	5	6
Other related causes†	24	—	—	2	—	3	2	6	3	5	2	—	1	—
Unrelated causes‡	288	4	10	13	7	10	29	33	38	42	33	28	33	8
	MALE CIGARETTE SMOKERS CONTINUING, 25 OR MORE/DAY*													
Number of person-years at risk	30, 141	603	2, 172	4, 071	5, 103	5, 074	4, 748	3, 830	2, 232	1, 254	660	283	92	19
Number of deaths:														
All causes	459	1	5	15	29	32	66	72	75	69	51	24	16	4
Cancer of the lung	52	—	—	—	1	3	5	13	12	7	5	4	2	—
Chronic bronchitis	15	—	—	—	—	1	1	1	1	2	4	4	1	—
Coronary disease*	127	—	—	6	9	7	18	28	20	24	9	4	2	—
Other related causes†	34	—	—	1	4	1	8	6	5	7	1	1	—	—
Unrelated causes‡	231	1	5	8	15	20	34	24	37	29	32	11	11	4

See footnotes at end of Appendix table 5.

APPENDIX TABLE 5.—Number of person-years at risk, by age, and number of deaths, by age and cause, according to smoking habits (allowing for changes in smoking habits recorded in 1957 questionnaire—Method of analysis B). British doctors, males, 1951–61—Continued

	All ages	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85 and over
	MALE EX-CIGARETTE SMOKERS, LAST SMOKED 1–14/DAY, STOPPED LESS THAN 5 YEARS*													
Number of person-years at risk	3, 928	162	487	704	606	486	433	302	222	156	137	129	72	32
Number of deaths:														
All causes	47	—	—	—	2	2	3	4	4	5	5	8	8	6
Cancer of the lung	1	—	—	—	—	—	—	—	—	—	—	1	—	—
Chronic bronchitis	2	—	—	—	—	—	—	—	—	—	—	2	—	—
Coronary disease*	16	—	—	—	—	1	2	1	3	4	2	2	—	1
Other related causes†	2	—	—	—	—	—	—	1	—	—	—	1	—	—
Unrelated causes‡	26	—	—	—	2	1	1	2	1	1	3	2	8	5
	MALE EX-CIGARETTE SMOKERS, LAST SMOKED 1–14/DAY, STOPPED 5–9 YEARS*													
Number of person-years at risk	6, 034	119	732	1, 096	983	741	575	539	369	279	231	176	120	74
Number of deaths:														
All causes	80	—	—	—	3	3	4	4	3	8	8	16	19	12
Cancer of the lung	1	—	—	—	—	—	—	—	—	1	—	—	—	—
Chronic bronchitis	3	—	—	—	—	—	1	—	—	—	—	1	1	—
Coronary disease*	19	—	—	—	1	1	—	2	1	3	2	4	4	1
Other related causes†	2	—	—	—	1	—	—	—	—	—	—	—	—	1
Unrelated causes‡	55	—	—	—	1	2	3	2	2	4	6	11	14	10

MALE EX-CIGARETTE SMOKERS, LAST SMOKED 1–14/DAY, STOPPED 10–19 YEARS*

Number of person-years at risk	4, 829	9	187	683	885	766	593	446	356	294	229	166	132	83
Number of deaths:														
All causes	74	1	—	—	2	10	1	4	7	5	6	8	15	15
Cancer of the lung	1	—	—	—	—	—	—	—	1	—	—	—	—	—
Chronic bronchitis	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Coronary disease*	17	—	—	—	—	2	—	3	—	3	3	2	2	2
Other related causes†	1	—	—	—	1	—	—	—	—	—	—	—	—	—
Unrelated causes‡	55	1	—	—	1	8	1	1	6	2	3	6	13	13

MALE EX-CIGARETTE SMOKERS, LAST SMOKED 1–14/DAY, STOPPED 20 YEARS OR MORE*

Number of person-years at risk	2, 407	0	1	26	180	303	311	293	283	275	227	220	162	126
Number of deaths:														
All causes	76	—	—	—	—	—	—	2	2	6	6	14	19	27
Cancer of the lung	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Chronic bronchitis	2	—	—	—	—	—	—	—	—	1	—	—	1	—
Coronary disease*	14	—	—	—	—	—	—	—	—	1	2	4	4	3
Other related causes†	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Unrelated causes‡	60	—	—	—	—	—	—	2	2	4	4	10	14	24

See footnotes at end of Appendix table 5.

APPENDIX TABLE 5.—Number of person-years at risk, by age, and number of deaths, by age and cause, according to smoking habits (allowing for changes in smoking habits recorded in 1957 questionnaire—Method of analysis B). British doctors, males, 1951–61—Continued

	All ages	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85 and over
	MALE EX-CIGARETTE SMOKERS, LAST SMOKED 15–24/DAY, STOPPED LESS THAN 5 YEARS*													
Number of person-years at risk	3, 406	115	390	589	578	447	411	312	235	142	93	55	30	9
Number of deaths:														
All causes	22	—	—	3	—	1	1	4	1	1	3	3	3	2
Cancer of the lung	1	—	—	—	—	—	—	—	—	1	—	—	—	—
Chronic bronchitis	1	—	—	—	—	—	—	1	—	—	—	—	—	—
Coronary disease*	6	—	—	—	—	1	—	2	1	—	1	—	1	—
Other related causes†	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Unrelated causes‡	14	—	—	3	—	—	1	1	—	—	2	3	2	2
	MALE EX-CIGARETTE SMOKERS, LAST SMOKED 15–24/DAY, STOPPED 5–9 YEARS*													
Number of person-years at risk	5, 122	33	425	789	877	757	663	547	399	246	178	128	71	9
Number of deaths:														
All causes	62	—	—	2	—	5	3	5	13	5	9	9	8	3
Cancer of the lung	2	—	—	—	—	—	—	—	1	1	—	—	—	—
Chronic bronchitis	4	—	—	—	—	—	—	—	1	—	1	1	1	—
Coronary disease*	22	—	—	—	—	2	—	2	8	1	3	4	2	—
Other related causes†	3	—	—	—	—	—	—	1	1	—	—	1	—	—
Unrelated causes‡	31	—	—	2	—	3	3	2	2	3	5	3	5	3

	MALE EX-CIGARETTE SMOKERS, LAST SMOKED 15–24/DAY, STOPPED 10–19 YEARS*													
Number of person-years at risk	3, 427	1	46	269	468	533	557	535	372	277	158	88	71	52
Number of deaths:														
All causes	55	—	—	1	—	1	3	4	7	9	8	7	7	8
Cancer of the lung	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Chronic bronchitis	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Coronary disease*	16	—	—	—	—	—	—	1	5	2	4	2	—	2
Other related causes†	2	—	—	—	—	—	—	—	1	—	1	—	—	—
Unrelated causes‡	37	—	—	1	—	1	3	3	1	7	3	5	7	6
	MALE EX-CIGARETTE SMOKERS, LAST SMOKED 15–24/DAY, STOPPED 20 YEARS OR MORE*													
Number of person-years at risk	1, 032	0	0	0	18	47	111	207	176	136	153	90	51	43
Number of deaths:														
All causes	38	—	—	—	—	1	2	1	3	2	7	6	7	9
Cancer of the lung	1	—	—	—	—	—	—	—	—	—	1	—	—	—
Chronic bronchitis	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Coronary disease*	9	—	—	—	—	1	—	—	1	1	1	—	2	3
Other related causes†	1	—	—	—	—	—	—	—	—	—	1	—	—	—
Unrelated causes‡	27	—	—	—	—	—	2	1	2	1	4	6	5	6

See footnotes at end of Appendix table 5.

APPENDIX TABLE 5.—Number of person-years at risk, by age, and number of deaths, by age and cause, according to smoking habits (allowing for changes in smoking habits recorded in 1957 questionnaire—Method of analysis B). British doctors, males, 1951–61—Continued

	All ages	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85 and over
	MALE EX-CIGARETTE SMOKERS, LAST SMOKED 25 OR MORE/DAY, STOPPED LESS THAN 5 YEARS*													
Number of person-years at risk	1, 905	38	132	246	308	282	332	250	164	73	44	29	5	2
Number of deaths:														
All causes	22	1	—	—	1	3	2	4	3	1	3	3	1	—
Cancer of the lung	3	—	—	—	—	—	—	—	1	1	—	—	1	—
Chronic bronchitis	2	—	—	—	—	—	—	—	1	—	1	—	—	—
Coronary disease*	6	—	—	—	—	1	1	1	—	—	1	2	—	—
Other related causes†	2	—	—	—	—	—	—	1	—	—	—	1	—	—
Unrelated causes‡	9	1	—	—	1	2	1	2	1	—	1	—	—	—
	MALE EX-CIGARETTE SMOKERS, LAST SMOKED 25 OR MORE/DAY, STOPPED 5–9 YEARS*													
Number of person-years at risk	3, 513	10	171	400	514	579	590	538	301	217	103	53	32	5
Number of deaths:														
All causes	62	—	—	2	1	2	4	15	13	8	9	1	7	—
Cancer of the lung	3	—	—	—	—	—	1	—	1	—	—	—	1	—
Chronic bronchitis	4	—	—	—	—	—	1	—	1	—	1	—	1	—
Coronary disease*	20	—	—	—	—	—	1	7	2	4	6	—	—	—
Other related causes†	1	—	—	—	—	—	—	—	—	1	—	—	—	—
Unrelated causes‡	34	—	—	2	1	2	1	8	9	3	2	1	5	—

	MALE EX-CIGARETTE SMOKERS, LAST SMOKED 25 OR MORE/DAY, STOPPED 10–19 YEARS*													
Number of person-years at risk	2, 999	2	15	106	296	396	558	570	425	267	186	106	58	14
Number of deaths:														
All causes	75	—	—	—	1	2	5	6	13	13	14	9	11	1
Cancer of the lung	2	—	—	—	—	—	—	—	—	1	—	—	1	—
Chronic bronchitis	1	—	—	—	—	—	—	—	—	—	1	—	—	—
Coronary disease*	26	—	—	—	—	—	1	4	7	5	3	2	3	1
Other related causes†	2	—	—	—	—	—	—	1	1	—	—	—	—	—
Unrelated causes‡	44	—	—	—	1	2	4	1	5	7	10	7	7	—
	MALE EX-CIGARETTE SMOKERS, LAST SMOKED 25 OR MORE/DAY, STOPPED 20 YEARS OR MORE*													
Number of person-years at risk	958	0	0	0	6	29	75	149	184	189	154	106	40	26
Number of deaths:														
All causes	39	—	—	—	—	—	—	1	4	4	14	7	5	4
Cancer of the lung	1	—	—	—	—	—	—	—	—	—	1	—	—	—
Chronic bronchitis	2	—	—	—	—	—	—	—	—	—	1	1	—	—
Coronary disease*	17	—	—	—	—	—	—	1	3	2	5	3	3	—
Other related causes†	1	—	—	—	—	—	—	—	—	—	1	—	—	—
Unrelated causes‡	18	—	—	—	—	—	—	—	1	2	6	3	2	4

See footnotes at end of Appendix table 5.

APPENDIX TABLE 5.—Number of person-years at risk, by age, and number of deaths, by age and cause, according to smoking habits (allowing for changes in smoking habits recorded in 1957 questionnaire—Method of analysis B). British doctors, males, 1951–61—Continued

	All ages	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85 and over
	MALE PIPE AND/OR CIGAR SMOKERS CONTINUING TO SMOKE*													
Number of person-years at risk	28, 512	1, 070	2, 753	3, 574	3, 579	2, 967	2, 749	2, 555	2, 064	1, 967	1, 844	1, 666	1, 111	613
Number of deaths:														
All causes	547	1	5	1	7	8	16	27	32	35	75	106	111	123
Related causes†	183	—	—	1	2	4	6	13	14	19	37	41	30	16
Unrelated causes‡	364	1	5	—	5	4	10	14	18	16	38	65	81	107
	MALE PIPE AND/OR CIGAR SMOKERS STOPPED LESS THAN 5 YEARS*													
Number of person-years at risk	1, 557	56	148	219	215	214	162	128	93	94	82	69	47	30
Number of deaths:														
All causes	82	—	—	1	3	2	3	2	3	6	12	19	17	14
Related causes†	21	—	—	—	—	—	—	1	2	5	2	5	4	2
Unrelated causes‡	61	—	—	1	3	2	3	1	1	1	10	14	13	12
	MALE PIPE AND/OR CIGAR SMOKERS STOPPED 5 YEARS OR MORE*													
Number of person-years at risk	5, 276	58	283	531	527	502	525	529	441	470	464	409	340	197
Number of deaths:														
All causes	128	—	1	2	—	1	2	2	6	7	7	27	30	43
Related causes†	29	—	—	—	—	—	1	—	—	5	3	10	7	3
Unrelated causes‡	99	—	1	2	—	1	1	2	6	2	4	17	23	40

*See pages 216 and 217 for definitions of disease categories and smoking habits.
†Diseases for which association with smoking was revealed.
‡Diseases for which no association with smoking was revealed.

APPENDIX TABLE 6.—Number of person-years at risk, by age, and number of deaths, by age and cause, according to smoking and inhalation habits (Method of analysis C). British doctors, males, 1958–62

	All ages	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85 and over
	MALE NONSMOKERS*													
Number of person-years at risk	20, 452	54	2, 433	4, 485	3, 667	3, 011	2, 078	1, 677	1, 200	651	490	290	236	180
Number of deaths:														
All causes	166	—	4	2	6	7	14	14	16	13	13	18	21	38
Cancer of the lung	1	—	—	—	1	—	—	—	—	—	—	—	—	—
Chronic bronchitis	1	—	—	—	—	—	—	—	—	—	—	1	—	—
Coronary disease*	50	—	—	—	—	1	6	3	10	4	5	7	6	8
Other related causes	2	—	—	—	1	—	—	—	—	—	1	—	—	—
Unrelated causes	112	—	4	2	4	6	8	11	6	9	7	10	15	30
	MALE CIGARETTE SMOKERS CONTINUING, INHALERS, 1–14/DAY*													
Number of persons-years at risk	8, 120	9	704	1, 605	1, 543	1, 338	836	712	602	312	186	148	83	42
Number of deaths:														
All causes	105	—	—	6	3	7	7	8	16	12	9	15	10	12
Cancer of the lung	11	—	—	—	1	1	1	—	3	2	—	2	1	—
Chronic bronchitis	1	—	—	—	—	—	—	—	—	—	—	1	—	—
Coronary disease*	35	—	—	2	—	2	2	3	6	5	4	6	4	1
Other related causes	4	—	—	—	—	—	1	1	1	1	—	—	—	—
Unrelated causes	54	—	—	4	2	4	3	4	6	4	5	6	5	11

See footnote at end of Appendix table 6.

Appendix table 6.—Number of person-years at risk, by age, and number of deaths, by age and cause, according to smoking and inhalation habits (Method of analysis C). British doctors, males, 1958–62—Continued

	All ages	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85 and over
	MALE CIGARETTE SMOKERS CONTINUING, INHALERS, 15–24/DAY*													
Number of person-years at risk	11, 989	20	900	2, 342	2, 467	2, 056	1, 368	1, 170	828	389	285	109	37	18
Number of deaths:														
All causes	134	—	1	1	8	7	12	24	25	18	22	11	3	2
Cancer of the lung	13	—	—	—	—	—	2	2	2	1	3	2	1	—
Chronic bronchitis	7	—	—	—	—	—	1	—	1	2	2	1	—	—
Coronary disease*	45	—	—	—	4	4	4	12	6	2	9	3	1	—
Other related causes	6	—	—	—	—	1	1	1	—	2	1	—	—	—
Unrelated causes	63	—	1	1	4	2	4	9	16	11	7	5	1	2
	MALE CIGARETTE SMOKERS CONTINUING, INHALERS, 25 OR MORE/DAY*													
Number of person-years at risk	7, 266	2	283	905	1, 272	1, 413	1, 151	995	739	340	120	41	5	0
Number of deaths:														
All causes	106	—	—	2	9	8	6	26	20	20	6	5	4	—
Cancer of the lung	8	—	—	—	—	1	1	3	—	1	1	—	1	—
Chronic bronchitis	4	—	—	—	—	—	—	—	—	2	2	—	—	—
Coronary disease*	33	—	—	1	3	2	1	11	5	9	—	—	1	—
Other related causes	7	—	—	—	1	—	—	1	3	2	—	—	—	—
Unrelated causes	54	—	—	1	5	5	4	11	12	6	3	5	2	—

MALE CIGARETTE SMOKERS CONTINUING, NONINHALERS, 1–14/DAY*

Number of person-years at risk	3, 912	0	115	345	435	494	505	594	524	250	238	184	145	83
Number of deaths:														
All causes	75	—	—	1	—	2	1	6	9	10	5	13	14	14
Cancer of the lung	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Chronic bronchitis	4	—	—	—	—	—	—	—	1	—	—	2	—	1
Coronary disease*	27	—	—	1	—	2	—	2	3	5	3	4	4	3
Other related causes	1	—	—	—	—	—	—	—	—	—	—	—	—	1
Unrelated causes	43	—	—	—	—	—	1	4	5	5	2	7	10	9

MALE CIGARETTE SMOKERS CONTINUING, NONINHALERS, 15–24/DAY*

Number of person-years at risk	2, 698	0	72	204	304	447	411	409	346	227	134	81	35	28
Number of deaths:														
All causes	68	—	—	1	—	1	4	4	12	11	9	7	9	10
Cancer of the lung	4	—	—	—	—	—	—	1	3	—	—	—	—	—
Chronic bronchitis	3	—	—	—	—	—	—	—	1	—	1	—	—	1
Coronary disease*	24	—	—	1	—	—	1	3	5	6	4	—	1	3
Other related causes	1	—	—	—	—	—	—	—	—	1	—	—	—	—
Unrelated causes	36	—	—	—	—	1	3	—	3	4	4	7	8	6

MALE CIGARETTE SMOKERS CONTINUING, NONINHALERS, 25 OR MORE/DAY*

Number of person-years at risk	1, 740	2	16	61	166	216	295	347	271	162	124	57	17	6
Number of deaths:														
All causes	38	—	—	—	2	4	3	2	9	7	5	3	2	1
Cancer of the lung	7	—	—	—	—	1	1	1	1	—	1	1	1	—
Chronic bronchitis	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Coronary disease*	9	—	—	—	1	—	—	1	3	4	—	—	—	—
Other related causes	2	—	—	—	1	—	—	—	1	—	—	—	—	—
Unrelated causes	20	—	—	—	—	3	2	—	4	3	4	2	1	1

*See pages 216 and 217 for definitions of disease categories and smoking habits.

APPENDIX TABLE 7.—Number of person-years at risk, by age, and number of deaths, by age and cause, according to selected smoking habit characteristics. British doctors, females, 1951–62*

	All ages	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85 and over
FEMALE NONSMOKERS†														
Number of person-years at risk	32, 075	2, 658	5, 119	5, 250	3, 576	2, 689	3, 030	3, 489	2, 645	1, 443	923	670	377	206
Number of deaths:														
All causes	221	2	6	5	8	4	8	21	24	21	22	24	37	39
Coronary disease†	33	—	—	—	—	—	1	4	3	5	9	4	4	3
Other related causes‡	3	—	—	—	—	—	—	—	1	—	—	1	—	1
Unrelated causes§	185	2	6	5	8	4	7	17	20	16	13	19	33	35
FEMALE CIGARETTE SMOKERS STOPPED†														
Number of person-years at risk	8, 497	320	907	1, 316	1, 201	925	957	1, 147	873	414	241	140	44	12
Number of deaths:														
All causes	53	—	—	1	1	3	5	8	14	3	4	4	7	3
Coronary disease†	7	—	—	—	—	—	1	—	2	—	—	1	2	1
Other related causes‡	3	—	—	—	—	—	—	—	3	—	—	—	—	—
Unrelated causes§	43	—	—	1	1	3	4	8	9	3	4	3	5	2
FEMALE CIGARETTE SMOKERS CONTINUING, 1–14/DAY†														
Number of person-years at risk	15, 050	1, 142	2, 362	2, 579	1, 835	1, 419	1, 592	1, 786	1, 266	529	267	152	85	38
Number of deaths:														
All causes	66	—	1	4	4	—	4	10	13	6	5	5	9	5
Coronary disease†	4	—	—	—	—	—	—	1	1	—	1	1	—	—
Other related causes‡	1	—	—	1	—	—	—	—	—	—	—	—	—	—
Unrelated causes§	61	—	1	3	4	—	4	9	12	6	4	4	9	5

	FEMALE CIGARETTE SMOKERS CONTINUING, 15–24/DAY†													
Number of person-years at risk	7, 123	398	954	1, 185	955	764	828	922	662	269	114	49	13	10
Number of deaths:														
All causes	54	1	1	2	7	1	5	9	13	7	2	3	—	3
Coronary disease†	9	—	—	—	1	—	—	1	5	2	—	—	—	—
Other related causes‡	7	—	—	—	—	—	—	2	3	2	—	—	—	—
Unrelated causes§	38	1	1	2	6	1	5	6	5	3	2	3	—	3
	FEMALE CIGARETTE SMOKERS CONTINUING, 25 OR MORE/DAY†													
Number of person-years at risk	2, 587	67	183	287	340	384	485	474	257	61	24	16	5	4
Number of deaths:														
All causes	20	—	—	—	2	1	2	8	3	2	2	—	—	—
Coronary disease†	3	—	—	—	—	—	—	1	—	1	1	—	—	—
Other related causes‡	2	—	—	—	—	—	—	2	—	—	—	—	—	—
Unrelated causes§	15	—	—	—	2	1	2	5	3	1	1	—	—	—

*All women were classified in one or other of the 5 smoking categories tabulated. Data for all women can be obtained by addition.
†*See* pages 216 and 217 for definitions of disease categories and smoking habits.
‡Diseases for which association with smoking was revealed.
§Diseases for which no association with smoking was revealed.

Appendix table 8.—List of lung cancer deaths. British doctors, males, 1951–61*

Date of death (day, month, year)	Diagnostic grade	Histological type	Place of residence	Age at death	Smoking habits at 1 Nov. 1951
9/11/51	1	2	4	64	Ex-C 30 (1 yr)
22/12/51	2	—	2	64	C 20
19/ 1/52	1	1	4	73	Ex-C 50 (30 yrs)
19/ 1/52	1	4	4	57	Ex-M 37 (4 yrs)
10/ 3/52	3	—	2	78	C 13
3/ 4/52	1	1	1	76	Ex-C 04 (1 yr)
4/ 5/52	1	1	2	52	C 20
28/ 5/52	2	—	3	76	C 05
2/ 8/52	1	2	2	67	Ex-cigar 15 (13 yrs)
13/ 9/52	1	1	2	58	C 40
25/10/52	3	—	1	66	Ex-C 18 (3 yrs)
22/12/52	1	3	1	56	C 20
2/ 1/53	2	—	1	63	M 34
16/ 1/53	1	1	1	55	C 02
7/ 1/53	2	—	4	61	P 24
1/ 4/53	1	2	1	65	C 30
25/ 5/53	1	1	2	52	C 25
19/ 6/53	2	—	4	70	Ex-M 13 (3 yrs)
22/ 6/53	2	—	4	81	Ex-C 25 (12 yrs)
22/ 6/53	2	—	4	79	M 15
—/ 8/53	1	2	1	60	C 33
29/ 8/53	1	2	2	59	C 40
30/ 9/53	1	2	1	66	Ex-C 25 (18 yrs)
23/10/53	2	—	1	44	Ex-M 28 (3 yrs)
15/11/53	3	—	1	86	M 12
1/ 1/54	2	—	3	65	P 24
6/ 1/54	2	—	3	52	C 20
9/ 1/54	2	—	3	74	M 12
16/ 1/54	1	3	3	75	P 14
2/ 2/54	1	2	1	77	C 10
3/ 2/54	1	1	4	55	M 20
14/ 2/54	1	3	1	64	C 03
27/ 2/54	1	2	1	53	M 34
3/ 3/54	2	—	3	49	C 13
11/ 3/54	1	2	1	54	C 18
25/ 3/54	2	—	1	71	M 14
31/ 3/54	2	—	3	87	C 20
22/ 4/54	2	—	2	67	C 18
26/ 5/54	2	—	1	62	C 25
4/ 6/54	1	2	2	67	M 25
25/ 7/54	2	—	2	67	Ex-P 18 (7 yrs)
30/ 7/54	1	2	2	51	Ex-M 13 (6 yrs)
13/ 8/54	2	—	1	73	M 48
29/ 8/54	2	—	4	56	C 35
3/ 9/54	3	—	1	71	C 15
9/ 9/54	1	1	1	68	C 20
22/ 9/54	2	—	4	81	P 12
23/ 9/54	1	1	4	65	C 25
24/ 9/54	2	—	4	63	C 23
29/ 9/54	1	4	1	76	M 40
13/10/54	1	2	2	65	M 36
1/10/54	2	—	3	79	Nonsmoker
20/10/54	2	—	1	63	C 30
21/10/54	2	—	1	68	C 40
13/11/54	2	—	2	66	C 30
14/ 1/55	3	—	1	68	M 18
15/ 1/55	1	2	3	73	C 25
2/ 2/55	2	—	1	58	C 30
12/ 3/55	1	1	4	69	C 07
13/ 3/55	3	—	1	70	P 12
17/ 3/55	2	—	2	68	C 15
28/ 4/55	3	—	3	80	M 03

See footnotes at end of Appendix table 8.

Appendix table 8.—List of lung cancer deaths. British doctors, males, 1951–61*—Con.

Date of death (day, month, year)	Diagnostic grade	Histological type	Place of residence	Age at death	Smoking habits at 1 Nov. 1951
1/ 5/55	2	—	3	61	C 30
11/ 5/55	1	2	3	70	C 13
2/ 6/55	1	1	1	54	C 20
27/ 7/55	2	—	3	72	C 20
3/ 8/55	1	1	1	75	P 15
8/ 8/55	1	4	1	61	C 35
27/ 8/55	1	1	1	74	C 12
20/ 9/55	1	2	1	62	C 40
24/ 9/55	1	1	1	62	M 37
24/ 9/55	1	1	2	55	C 25
27/ 9/55	2	—	2	71	C 25
9/10/55	2	—	3	78	C 20
28/10/55	2	—	3	68	M 24
1/11/55	3	—	4	83	M 13
12/11/55	1	1	3	56	C 25
16/11/55	1	1	1	70	P 24
23/12/55	1	1	3	76	C 25
8/ 1/56	1	2	1	57	C 20
15/ 2/56	2	—	1	69	Ex-C 23 (7 yrs)
16/ 2/56	4	—	3	74	C 14
18/ 2/56	2	—	1	76	C 09
21/ 2/56	2	—	1	73	C 20
27/ 2/56	2	—	2	85	M 04
8/ 3/56	2	—	2	74	M 07
16/ 3/56	2	—	2	77	C 35
26/ 4/56	2	—	1	71	P 20
6/ 5/56	3	—	3	72	Ex-M 30 (8 yrs)
30/ 5/56	2	—	4	73	C 20
10/ 6/56	1	1	3	66	C 25
23/ 6/56	2	—	2	63	C 18
20/ 7/56	1	1	2	63	Ex-C 06 (10 yrs)
2/ 9/56	2	—	4	69	C 11
11/ 9/56	2	—	1	66	M 10
19/ 9/56	2	—	1	59	C 25
20/ 9/56	1	2	2	56	M 16
30/ 9/56	1	1	4	51	C 16
1/10/56	1	3	1	57	C 30
18/11/56	3	—	4	79	Nonsmoker
23/11/56	3	—	1	74	C 40
24/11/56	1	1	2	61	Ex-C 25 (5 yrs)
13/12/56	1	1	3	70	C 20
23/ 1/57	2	—	4	75	M 13
26/ 1/57	1	2	3	48	C 25
26/ 1/57	1	4	1	63	C 15
28/ 2/57	2	—	1	69	C 20
3/ 4/57	1	1	2	61	C 30
28/ 4/57	1	2	1	51	C 20
3/ 5/57	2	—	2	80	C 20
26/ 5/57	1	3	1	37	Ex-M 07 (10 yrs)
29/ 5/57	1	2	3	63	C 60
7/ 6/57	1	1	4	58	M 34
14/ 6/57	1	1	1	76	C 15
11/ 7/57	1	1	1	58	C 23
13/ 7/57	1	1	4	54	C 40
26/ 7/57	1	2	4	56	P 40
14/ 8/57	1	2	2	57	M 27
26/ 8/57	1	1	3	72	C 09
12/10/57	1	1	1	62	C 30
16/10/57	1	1	4	71	C 02
17/10/57	2	—	4	90	P 08
18/10/57	1	1	1	51	C 25
23/10/57	1	1	2	75	C 12

See footnotes at end of Appendix table 8.

781–871—65——18

APPENDIX TABLE 8.—List of lung cancer deaths. British doctors, males, 1951–61*—Con.

Date of death (day, month, year)	Diagnostic grade	Histological type	Place of residence	Age at death	Smoking habits at 1 Nov. 1951
2/11/57	2	—	4	67	C 28
13/11/57	1	3	2	58	C 50
19/12/57	1	3	2	68	C 20
28/ 1/58	1	1	4	69	P 28
31/ 1/58	1	1	3	55	C 20
8/ 2/58	1	1	2	53	C 10
10/ 2/58	1	4	1	82	C 16
15/ 2/58	1	2	3	62	P 14
17/ 4/58	1	1	3	71	M 28
17/ 4/58	2	—	2	73	C 25
6/ 5/58	1	2	3	42	C 30
16/ 6/58	2	—	1	70	C 20
16/ 9/58	2	—	2	60	C 35
24/ 9/58	2	—	4	62	C 20
29/ 9/58	2	—	2	75	C 35
30/11/58	2	—	1	81	M 18
7/12/58	1	1	3	57	P 06
17/12/58	2	—	1	81	C 40
18/12/58	1	2	1	64	C 30
5/ 1/59	1	4	3	63	P 12
17/ 1/59	1	1	3	60	C 10
9/ 2/59	1	1	1	57	C 33
13/ 3/59	1	1	3	62	C 20
17/ 3/59	1	1	3	63	P 08
29/ 3/59	2	—	3	61	M 24
26/ 5/59	1	3	2	58	C 20
28/ 5/59	1	1	2	84	P 13
30/ 6/59	2	—	4	77	M 22
27/ 7/59	1	2	4	77	C 18
31/ 7/59	1	1	1	58	C 20
11/ 8/59	1	2	3	55	C 30
24/ 8/59	1	4	2	82	C 54
27/ 8/59	1	1	4	77	P 16
17/10/59	2	—	4	77	M 16
20/10/59	1	4	3	51	C 10
29/10/59	1	1	2	63	C 20
15/11/59	1	1	2	62	C 20
16/11/59	2	—	3	72	C 13
8/12/59	1	2	2	65	C 06
15/12/59	2	—	4	73	C 45
24/12/59	2	—	3	77	C 20
30/12/59	1	2	2	65	C 18
1/ 2/60	1	1	3	54	C 25
11/ 2/60	1	2	3	55	C 28
11/ 2/60	2	—	4	73	P 08
18/ 2/60	2	—	2	73	C 20
26/ 2/60	2	—	1	50	C 24
28/ 2/60	1	1	4	85	Ex-P 24 (25 yrs)
6/ 3/60	1	3	1	70	Ex-C 20 (24 yrs)
9/ 3/60	2	—	1	67	C 25
14/ 3/60	2	—	2	77	C 25
6/ 4/60	2	—	3	80	M 17
12/ 4/60	1	2	1	73	C 20
6/ 5/60	2	—	1	59	C 20
24/ 5/60	1	1	3	64	C 23
7/ 6/60	1	2	1	58	C 30
9/ 7/60	1	3	2	53	C 30
6/ 8/60	2	—	2	61	C 20
16/10/60	2	—	4	63	C 28
24/10/60	1	3	1	62	C 15
25/10/60	1	2	1	37	Nonsmoker
31/10/60	1	2	4	46	C 20

See footnotes at end of Appendix table 8.

APPENDIX TABLE 8.—List of lung cancer deaths. British doctors, males, 1951–61*—Con.

Date of death (day, month, year)	Diagnostic grade	Histological type	Place of residence	Age at death	Smoking habits at 1 Nov. 1951
2/11/60	2	—	2	84	C 30
9/12/60	1	2	1	46	C 28
10/12/60	1	2	1	59	M 32
13/12/60	1	3	1	59	Cigar 09
15/ 1/61	1	2	1	42	C 12
7/ 2/61	2	—	3	62	C 20
25/ 2/61	1	3	4	65	C 20
12/ 3/61	2	—	1	75	M 60
17/ 3/61	1	2	2	63	M 17
29/ 3/61	1	1	2	60	C 35
23/ 4/61	2	—	4	75	M 36
27/ 4/61	2	—	4	46	C 20
3/ 6/61	2	—	3	66	C 30
31/ 7/61	1	2	1	53	C 40
14/ 8/61	1	1	1	56	P 34
31/ 8/61	1	1	3	61	M 55
11/ 9/61	3	—	2	65	P 12
15/ 9/61	2	—	3	81	C 25
26/ 9/61	1	1	1	62	C 22
22/10/61	2	—	1	80	C 10
30/10/61	1	4	3	83	M 25
4/10/52 †	2	—	1	77	M 07
10/ 4/54 †	1	4	3	75	C 20
23/ 9/54 †	2	—	1	67	C 25
20/ 5/59 †	1	1	2	69	C 20
26/ 7/60 †	1	2	5	70	C 18

* *Code:*

Diagnostic grade: 1. Necropsy evidence or histological or cytological evidence together with evidence of primary site from operation, bronchoscopy, or X ray. 2. Clinical evidence together with evidence of primary from operation, bronchoscopy, or X ray. 3. Evidence from history and physical examination without positive evidence to justify inclusion in grades 1 or 2. 4. No information obtained.

Histological type: 1. Squamous carcinoma. 2. Oat-cell or anaplastic carcinoma. 3. Adenocarcinoma. 4. Carcinoma type not specified.

Place of residence: 1. Conurbation. 2. Other towns of more than 50,000 population. 3. Towns of less than 50,000 population. 4. Rural area.

Smoking habits: C. Current smoker of cigarettes, not known to have smoked pipes or cigars regularly. M. Current smoker, with either current or post regular smoking of cigarettes and of pipes or cigars. P. Current pipe smoker, not known to have smoked cigarettes regularly.

Ex-C, Ex-M, Ex-P } As above, but ex-smoker instead of current smoker.

Nonsmoker. Never smoked as much as 1 cigarette a day, or the equivalent in pipe tobacco or cigars, regularly for 1 year.

The number following the code letter indicates the number of cigarettes smoked per day when reply to the questionnaire was made or when smoking was last stopped; 1 oz of pipe tobacco a week is regarded as equivalent to 4 cigarettes (4 g) a day, 1 large cigar as equivalent to 5 cigarettes (5 g), and 1 small cigar to 3 cigarettes (3 g).

† Lung cancer referred to as a contributory cause of death and not the underlying cause (*see also* Appendix table 10).

Appendix table 9.—List of deaths from cancers of the upper respiratory and digestive tracts. British doctors, males, 1951–61

Date of death (day, month, year)	Age at death	Smoking habits* at 1 Nov. 1951
MOUTH, PHARYNX, AND NOSE		
—/ 4/53	65	Ex-C 30 (20 yrs)
31/ 1/54	77	Ex-M 28 (13 yrs)
30/11/54	81	P 08
12/11/56	68	C 40
10/ 2/57	78	P 14
20/ 2/57	68	M 34
15/ 3/57	63	C 35
4/12/57	71	M 31
23/12/57	83	Ex-P 23 (39 yrs)
8/ 4/58	84	P 08
16/ 8/58	75	Ex-M 59 (23 yrs)
10/12/58	66	C 20
3/ 6/59	55	M 25
7/ 2/60	75	C 65
3/ 3/60	80	Ex-M 26 (25 yrs)
3/ 8/61	90	C 10
3/ 8/61	65	C 25
LARYNX AND TRACHEA		
1/ 8/54	77	C 11
23/ 9/54	67	C 25
4/10/55	54	C 30
30/ 4/56	63	Ex-P 06 (5 yrs)
24/ 2/57	55	P 16
25/ 3/57	57	C 20
29/10/59	55	C 40
4/ 5/60 †	78	Ex-P 12 (31 yrs)
20/ 6/60	60	C 75
2/10/60	65	M 26
29/11/60	55	C 40
ESOPHAGUS		
17/11/53	69	M 34
18/ 1/54	74	C 15
7/ 5/54	62	M 18
18/12/54	83	M 12
31/ 3/55	82	M 10
19/ 5/55	65	M 13
1/ 8/55	68	M 04
25/ 3/56	63	M 07
26/ 6/56	75	P 09
22/ 8/56	60	C 20
28/ 8/56	68	Ex-C 30 (9 yrs)
6/ 9/56	72	Nonsmoker
12/ 8/57	85	M 28
2/ 3/58	52	M 22
2/ 4/58	89	M 16
5/ 9/58	79	P 28
9/11/58	64	C 25
11/ 1/59	80	Ex-M 05 (11 yrs)
21/ 2/59	54	M 34
18/ 3/59	63	M 20
25/ 8/59	54	C 20
16/ 2/60	69	C 20
16/ 8/60	46	P 24
24/ 8/60	60	M 12
15/ 9/60	60	M 28
15/ 9/60	65	C 24
13/10/60	69	C 35
—/ 5/61	75	P 08

* *See* footnote at end of Appendix table 8 for code on smoking habits.

† Cancer of trachea.

APPENDIX TABLE 10.—List of deaths from selected contributory causes. British doctors, males, 1951–61

Contributory cause (number of deaths)	Smoking habits at 1 Nov. 1951		Underlying cause (International List Nos.)	Age at death
Cancer of lung (5)	Cigarettes/day	18	155	70
		20	331	75
		20	420	69
		25	161	67
	Mixed g/day	07	434	77
Cancer of mouth (2)	Pipe g/day	40	162	56
	Mixed	32	540	63
Cancer of nasal sinus (1)	Mixed	10	332	81
Cancer of larynx (4)	Cigarettes	50	E	49
	Cigar g/day	02	521	71
	Ex-mixed	18 (11 yrs stopped)	420	79
		13 (13 yrs)	420	83
Cancer of esophagus (1)	Pipe	24	493	69
Cancer of bladder (2)	Cigarettes	25	502	67
	Mixed	22	422	73
Pulmonary tuberculosis (14)	Nonsmoker		480	50
			204	63
	Cigarettes	10	480	54
		11	420	73
		15	420	64
		20	162	65
		20	502	77
		30	442	57
	Ex-cigarette	04 (13 yrs)	193	33
		13 (8 yrs)	481	50
	Mixed	10	502	78
		10	422	82
	Pipe	04	491	84
		22	199	51
Peptic ulcer (15)	Nonsmoker		446	57
	Cigarettes	06	422	87
		10	420	74
		15	570	55
		18	420	70
		22	420	49
		23	420	77
		24	502	64
		30	204	50
	Ex-cigarette	08 (5 yrs)	422	81
		30 (21 yrs)	420	83
	Ex-mixed	18 (13 yrs)	420	81
		32 (13 yrs)	420	51
		48 (30 yrs)	332	64
	Pipe	16	420	53

Appendix table 11.—List of deaths from causes related to smoking other than coronary disease. British doctors, females, 1951–62

Cause of death (number of deaths)	Date of death (day, month, year)	Age at death	Smoking habits at 1 Nov. 1951	
Cancer of lung (7)	28/10/53	64	Cigarette/day	15
	3/ 4/55	55		30
	23/ 1/56	63		20
	13/ 7/58	55		20
	14/12/59	60	Ex-cigarette	40 (9 yrs stopped)
	16/ 3/61	63	Nonsmoker	
	23/12/61	63	Cigarette	20
Cancer of mouth (2)	26/ 9/61	57	Cigarette	30
	21/ 1/62	69		20
Chronic bronchitis (2)	9/12/51	36	Cigarette	08
	5/12/57	68		20
Pulmonary tuberculosis (1)	20/ 1/53	76	Nonsmoker	
Cirrhosis of liver and alcoholism (4)	14/ 1/53	85	Nonsmoker	
	18/ 4/56	61	Ex-cigarette	05 (31 yrs)
	13/ 9/61	64	Cigarette	10 (23 yrs)
	10/ 6/62	58		20
Peptic ulcer (0)				

Appendix table 12.—List of deaths erroneously attributed to coronary disease in Appendix tables 1 to 6

Corrected diagnosis (International List Nos.)	Date of death (day, month, year)	Age at death	Smoking habits*
434	21/ 9/52	71	Nonsmoker
422	20/ 9/53	74	Ex-M 18 (29 yrs)
422	15/10/54	85	Ex-C 6 (6 yrs)
422	14/12/54	78	Ex-M 28 (9 yrs)
422	6/ 5/55	77	Nonsmoker
422	23/ 7/56	61	M 28
422	3/ 6/61	84	Ex-M 28 (16 yrs)

* *See* footnote at end of Appendix table 8 for code on smoking habits.

The Influence of Health on Smoking Habits [1]

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A curious finding emerged from Harold F. Dorn's prospective study on veterans (*1*). Ex-cigar and ex-pipe smokers had higher death rates than current cigar and pipe smokers. However, ex-cigarette smokers had lower death rates than current cigarette smokers (*see* table 1). Essentially the same findings came from the prospective study by Hammond and Horn (*2*).

The latter authors published death rates of ex-cigarette smokers in relation to their former amount of smoking and to the time since they had last smoked cigarettes regularly (*see* table 2). Men who had given up cigarette smoking less than 1 year prior to enrollment in the study had *higher* death rates than those currently smoking cigarettes at enrollment. On the other hand, men who had stopped smoking cigarettes 1 year or longer before enrollment had lower death rates than men smoking cigarettes at enrollment, and the death rates decreased with length of time since last smoking.

The following hypothesis proposed as a partial explanation of these findings is:

> Illness sometimes leads a smoker to give up the habit. Thus ex-smokers, as a group, include a relatively large proportion of persons in ill health, and death rates are high among persons in ill health. This effect diminishes with time, due to selective mortality, since persons initially in poor health die more rapidly than persons initially in good health.

This hypothesis seemed reasonable, and it had support from a study of the reasons given by ex-smokers for stopping the habit (*3*). If true, it is very important in studies of health that relate to smoking. Furthermore, a similar problem may arise in studies of other personal factors, such as weight, diet, exercise, and sleep, that may have an influence on health and also be influenced by state of health. For these reasons, we have undertaken a further investigation.

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[1] This is a slight revision of a paper presented at the Harold F. Dorn Memorial Session on November 13, 1963, at the ninety-first annual meeting of the American Public Health Association, Kansas City, Mo.

TABLE 1.—Mortality ratio of men who never smoked, cigar smokers, pipe smokers, and cigarette smokers*

Type of smoking	Current use		
	Total	Smokes	Does not smoke
Never smoked	1.00	—	1.00
Cigar only	1.07	0.94	1.44
Pipe only	1.10	1.05	1.25
Cigarette only	1.58	1.65	1.39

*As reported by Dorn (*1*).

TABLE 2.—Mortality ratio of current cigarette smokers and ex-cigarette smokers.* The mortality ratio of men who never smoked was set at 1.00

Number of cigarettes smoked per day	Current cigarette smokers	Stopped (yrs)		
		1	1–10	10+
<20	1.61	2.04	1.30	1.08
20 or more	2.02	2.69	1.82	1.50

*As reported by Hammond and Horn (*2*).

MATERIAL

The data for this report are from a study described in some detail in another paper in this volume (*4*). Therefore, a brief description will suffice here.

Between October 1, 1959, and February 15, 1960, volunteer workers of the American Cancer Society enrolled a large number of families in a prospective epidemiological study. On enrollment, each person in these families over age 30 was requested to answer a confidential questionnaire including questions on past diseases, present state of health, and past and present smoking habits. These subjects are traced once a year. Once every 2 years, they are requested to answer follow-up questionnaires containing inquiries on their current cigarette smoking, their illnesses, and hospitalizations during the intervening 2 years.

The second follow-up started on October 1, 1961, was largely completed about February, 1962, but was not entirely finished until the end of that month. By that time, 96.8 percent of the subjects were traced, and a second questionnaire was filled out by 95.6 percent of those who were alive when traced. (Some of the subjects "lost" in that follow-up were traced in later years.) Changes in smoking habits of the subjects have been reported (*5*, *6*).

Most of the present analysis is based on data derived from the original questionnaire and the second one. It is confined to records of 327,932 men, between the ages of 45 and 69, who answered the questions on smoking habits on both the first and second questionnaires. Men in

age group 45 to 69 were selected because this group contained a fairly large number of pipe and cigar smokers as well as many cigarette smokers.

In addition to the above, some death rates are based on deaths reported between the start of the study and September 30, 1963. Extensive information on the death rates of the same subjects is reported in another paper (*4*).

It should be noted that the number of men, shown in certain tables in this paper, differs with the number shown in tables of the other paper (*4*). The reasons are that, except for table 8, this paper is confined to men who answered both the first and second questionnaires, and certain men not traced in the fourth follow-up are excluded from the other paper.

FINDINGS

A list of 22 different diseases was printed on the first questionnaire and the subject was asked to "make a check mark after the name of each of the following diseases you have ever had." The subject was also asked: "Are you sick at the present time?" For simplicity, in this analysis we will only consider answers to the questions on "sick at present" and on heart disease, stroke, and high blood pressure.

Table 3 shows the percentage of men who gave positive answers to these questions, the subjects being classified by their smoking habits as reported on the first questionnaire. The percentages are lower among current pipe and cigar smokers than among men who never smoked regularly, but the percentages are higher among ex-pipe and ex-cigar smokers than among men who never smoked regularly. These findings are in conformity with what Dorn might have expected. In commenting on his findings on pipe and cigar smokers he said: "These data suggest that many cigar and pipe smokers may have stopped smoking because of ill health . . ." (*1*).

The percentages of men who gave positive answers to questions on sickness and circulatory diseases were appreciably higher among current cigarette smokers than among men who never smoked regularly, and the percentages were higher among ex-cigarette smokers than among current cigarette smokers. Further details on this will be shown later.

Men who said that they were ex-cigarette smokers were asked why they gave up the habit. (Ex-cigar and ex-pipe smokers were not asked this question.) Table 4 shows the replies of ex-cigarette smokers between the ages of 50 and 69 who said they had stopped smoking less than 1 year before enrollment in the study. It is confined to men who had never smoked cigars or pipes regularly, and is divided into two groups on the basis of their answers to the question on "sick at present."

By far the most common general reason for giving up cigarette smoking was state of health, *e.g.*, "doctor's orders," some disease, or physical complaint. This reason was entered by 76.7 percent of those "sick at present" and by 56.8 percent of those not "sick at present." Most men

Table 3.—Number of men, percent who said they were "sick at present" and percent who reported a history of heart disease, stroke, or high blood pressure. Subjects classified by smoking habits as reported on first questionnaire

Age	Never smoked regularly	History of pipe or cigar smoking (no cigarette smoking)			History of cigarette smoking (with or without other smoking)			Unknown
		Total	Current smokers	Ex-smokers	Total	Current smokers	Ex-smokers	
				Number of men				
45–49	18, 616	6, 891	5, 498	1, 393	71, 845	56, 972	14, 873	129
50–54	18, 628	8, 307	6, 469	1, 838	69, 302	53, 089	16, 213	175
55–59	15, 432	7, 970	5, 937	2, 033	50, 537	36, 889	13, 648	175
60–64	12, 309	7, 631	5, 386	2, 245	33, 928	23, 150	10, 778	142
65–69	9, 911	6, 761	4, 477	2, 284	20, 833	13, 477	7, 356	138
Total	74, 896	37, 560	27, 767	9, 793	246, 445	183, 577	62, 868	759
				Percent who said they were "sick at present"				
45–49	5. 5	5. 2	4. 6	7. 5	6. 7	6. 5	7. 2	—
50–54	5. 8	5. 7	5. 1	8. 0	7. 6	7. 4	8. 4	—
55–59	6. 3	7. 1	6. 2	9. 6	8. 8	8. 3	10. 2	—
60–64	8. 0	8. 3	7. 1	11. 4	11. 2	10. 6	12. 6	—
65–69	9. 1	9. 3	7. 8	12. 3	12. 0	11. 2	13. 4	—
				Percent with a history of heart disease, stroke, or high blood pressure				
45–49	9. 9	11. 7	11. 1	14. 0	11. 3	10. 9	12. 9	—
50–54	12. 3	13. 3	12. 1	17. 4	14. 4	13. 5	17. 4	—
55–59	15. 1	16. 5	14. 7	22. 0	17. 8	16. 3	21. 9	—
60–64	19. 6	20. 3	17. 7	26. 6	22. 9	21. 0	27. 1	—
65–69	24. 4	24. 0	21. 4	29. 2	27. 1	24. 1	32. 5	—

Table 4.—Reasons why ex-cigarette smokers gave up the habit. Men between ages of 50–69 who had history of smoking cigarettes only and had stopped smoking less than 1 year before enrollment in study

Reason for stopping smoking	Sick at present		Not sick at present	
	Number	Percent	Number	Percent
Disease or physical complaint*	396	76. 7	1, 457	56. 8
Other reason	81	15. 7	943	36. 8
No answer	39	7. 6	163	6. 4
Total	516	100. 0	2, 563	100. 0
Doctor's orders	113	21. 9	275	10. 7
Heart, circulatory disease	98	19. 0	143	5. 6
Cough	42	8. 1	382	14. 9
Cold, flu, sinus, etc.	30	5. 8	166	6. 5
Other respiratory conditions	42	8. 1	140	5. 5
Ulcer or stomach trouble	18	3. 5	84	3. 3
Other diseases or complaints	73	14. 1	376	14. 7
Nonspecific (*e.g.*, "just quit")	64	12. 4	714	27. 9
Smoking-cancer reports	15	2. 9	174	6. 8
Cost, religion, etc.	13	2. 5	89	3. 5

*A few of these men also gave some other reason.

gave only one reason for quitting, but a few gave two or more specific reasons. Thus the percentages shown in table 4 for specific reasons add up to somewhat more than 100 percent. Among ex-cigarette smokers who were "sick at present," the most common specific reasons for quitting were "doctor's orders" and heart and circulatory diseases. Among those not "sick at present" the most common category was "just quit" (or some similar, nonspecific answer), while the most common health reason was "cough." Relatively few men said they had stopped cigarette smoking because of reports linking smoking to lung cancer and other diseases.

This evidence supports the hypothesis concerning the influence of health on smoking habits. However, an objection may be raised that the reasons given by ex-smokers for quitting the habit are subjective and perhaps inaccurate. Therefore, we examined a different type of evidence.

On the second questionnaire, the subjects were asked whether they had been hospitalized since October 1, 1959, this being the date on which subjects began to answer the first questionnaire. If hospitalized, they were asked why. They were also asked to name any serious diseases they had had since October 1, 1959. In addition, they were questioned as to their current cigarette smoking.

Table 5 shows the percentage of men who reported no cigarette smoking on the second questionnaire among men who on the first one said they were currently smoking cigarettes and had never smoked pipes or cigars regularly. The subjects are divided into groups on the basis of whether they had been hospitalized and whether they said they had had heart disease, stroke, or high blood pressure since October 1, 1959.

A considerable proportion of these 1959–60 current cigarette smokers said they were not smoking cigarettes regularly at the time they answered the second questionnaire in 1961–62. This proportion varied both with former amount of smoking and with age. The finding of interest here is that the percentage who had stopped smoking was far higher among those who had been hospitalized than among those who had not been, and the percentage was far higher among those who said they had had heart disease, stroke, or high blood pressure since October 1, 1959, than among those who did not report these diseases.

From this evidence it may be inferred that state of health has an influence on smoking habits. That is, smokers in poor health are more likely to give up the habit than smokers in good health; so ex-smokers, as a group, are weighted with persons in poor health and current smokers, as a group, are weighted with persons in good health. Thus, if smoking had no influence on death rates we would expect the following: (*a*) The death rate of all men with a history of smoking would be the same as that of men who never smoked; (*b*) ex-smokers would have higher death rates than men who never smoked; and (*c*) current smokers would have lower death rates than men who never smoked. However, if smoking increases death rates, and if giving it up results in a reduction of the ill effects, then the death rates of all men with a history of smoking would be higher than

Table 5.—Percentage of men who had stopped smoking cigarettes at time they filled out second questionnaire in relation to their current amount of cigarette smoking reported on first one. Men with history of only cigarette smoking classified by whether they were hospitalized or had circulatory disease* between time of first and second questionnaires

Current amount of cigarette smoking, first questionnaire	Hospitalized between questionnaires		Not hospitalized between questionnaires		Circulatory disease* between questionnaires		No circulatory disease between questionnaires	
	Number	Stopped smoking cigarettes (%)	Number	Stopped smoking cigarettes (%)	Number	Stopped smoking cigarettes (%)	Number	Stopped smoking cigarettes (%)
				Men aged 50–59 at time of enrollment				
1–9 a day	638	27.3	3,488	19.6	133	41.4	3,993	20.1
10–19 a day	1,493	17.0	7,605	9.4	328	30.2	8,770	9.9
20–39 a day	5,630	13.6	25,868	6.4	1,168	25.6	30,330	7.0
40+ a day	1,426	11.4	5,611	4.8	296	24.3	6,741	5.4
				Men aged 60–69 at time of enrollment				
1–9 a day	414	32.6	1,862	23.4	114	44.7	2,162	24.0
10–19 a day	876	20.8	3,319	12.7	252	23.0	3,943	13.9
20–39 a day	2,047	15.8	7,371	9.0	599	24.5	8,819	9.5
40+ a day	354	15.0	1,067	8.2	79	20.3	1,342	9.2

*Heart disease, stroke, or high blood pressure.

the death rates of men who never smoked. Under these circumstances, the relative death rates of current smokers, ex-smokers, and men who never smoked would depend on: (*a*) the degree of influence of health on smoking habits; (*b*) the degree of harm done by past and current smoking; and (*c*) the degree of benefit derived from giving up smoking.

Pipe and cigar smoking appear to fit the first of the two models described above. These forms of smoking seem to do relatively little harm as measured by their influence on total death rates, and giving up a habit which has little effect upon death rates is not likely to result in a lowering of death rates. On the other hand, ill health can lead pipe and cigar smokers to give up the habit, and high death rates accompany ill health. This would seem to explain the findings shown in text tables 12 and 13 of the other report on this study (*4*). The death rates of all men with a history of only pipe and cigar smoking were just slightly higher than those of men who never smoked regularly; but ex-pipe and ex-cigar smokers had higher death rates than current pipe and cigar smokers, respectively.

Cigarette smoking seems to fit the second of the two models. That is, cigarette smoking (particularly heavy cigarette smoking) does considerable harm, as measured by death rates, and when the habit is given up the risk is reduced. The net outcome is complicated by conditions illustrated in tables 6 and 7.

For simplicity, table 6 is confined to men with a history of regular cigarette smoking who had never smoked pipes or cigars and who answered all questions necessary for our inquiry. The percentage of men reporting that they were "sick at present" was far higher among ex-cigarette smokers, who had stopped smoking less than 1 year, than among current cigarette smokers. Among ex-cigarette smokers, the percentage "sick at present" decreased with time since last smoking. Those who had stopped smoking for 5 years or longer included about the same percentage of sick people as was found among current cigarette smokers.

The picture is somewhat different for the percent of men reporting a history of heart disease, stroke, or high blood pressure. The lowest percentages were among current cigarette smokers and next, ex-cigarette smokers who had stopped smoking for 10 years or longer. The percentages were generally highest among men who had stopped smoking for 1 year rather than among those who had stopped for less than 1 year.

The trends just mentioned may be partly due to selective mortality, but the tendency of recent ex-smokers to return to the habit may be equally important in this respect. This is illustrated in table 7 which is confined to men answering both the first and second questionnaires and who on the first questionnaire said they were ex-cigarette smokers, stated the time since they last smoked, and said they had never smoked pipes or cigars regularly. (We have no information concerning the later habits of those dying before the second questionnaires were distributed.) A large percentage of men who had stopped cigarette smoking for less than 1 year returned to the habit and were again smoking cigarettes regularly when they answered the second questionnaire. The percentage who re-

TABLE 6.—Number of men, percent who said they were "sick at present," and percent who reported a history of heart disease, stroke, or high blood pressure. Men with history of regular cigarette smoking (who never smoked pipes or cigars) classified by time since last smoking

Age	Current cigarette smokers (never smoked pipe, cigar)	Ex-cigarette smokers (never smoked pipes or cigars) stopped (yrs)				
		<1	1	2–4	5–9	10+
		Number of men				
45–49	40, 341	1, 402	716	2, 083	2, 901	3, 726
50–54	36, 284	1, 256	707	2, 135	2, 970	4, 451
55–59	23, 865	923	544	1, 653	2, 317	3, 946
60–64	13, 921	582	401	1, 217	1, 643	3, 051
65–69	7, 326	318	215	734	1, 020	2, 108
Total	121, 737	4, 481	2, 583	7, 822	10, 851	17, 282
	Percent who said they were "sick at present"					
45–49	6. 3	11. 1	8. 8	6. 8	6. 3	5. 6
50–54	7. 3	13. 8	12. 2	8. 4	6. 6	6. 8
55–59	8. 4	16. 4	14. 7	11. 1	8. 1	8. 6
60–64	10. 7	21. 5	15. 0	13. 0	11. 0	9. 9
65–69	11. 4	21. 1	15. 3	14. 9	10. 8	12. 5
Total	7. 8	15. 0	12. 5	9. 9	7. 9	8. 2
	Percent with a history of heart disease, stroke, or high blood pressure					
45–49	10. 8	12. 5	17. 5	14. 1	12. 0	11. 4
50–54	13. 5	19. 4	22. 9	19. 2	17. 4	15. 3
55–59	16. 3	23. 1	27. 0	25. 4	23. 6	18. 7
60–64	21. 0	28. 5	27. 4	30. 2	29. 0	24. 7
65–69	24. 5	34. 3	35. 3	30. 9	35. 9	30. 0
Total	14. 6	20. 2	24. 0	22. 0	20. 8	18. 7

TABLE 7.—Percent of ex-cigarette smokers in 1959–60 who were smoking cigarettes regularly in 1961–62. Men with history of regular cigarette smoking only

Years since last smoking * (1959–60)	Age 50–59			Age 60–69		
	Total	Smoking again in 1960–61: Number	Smoking again in 1960–61: Percent	Total	Smoking again in 1960–61: Number	Smoking again in 1960–61: Percent
<1	1, 956	733	37. 5	742	278	37. 5
1	1, 108	207	18. 7	537	87	16. 2
2–4	3, 387	315	9. 3	1, 674	126	7. 5
5–9	4, 746	211	4. 4	2, 289	77	3. 4
10+	7, 605	178	2. 3	4, 490	85	1. 9

* Ex-cigarette smokers not stating the time since last smoking are omitted.

turned to the habit was far less among those who had stopped smoking for 2 to 4 years and still less among those who had stopped for 5 years or longer.

The conditions described above would seem to explain the findings shown in text table 11 of the other report on this study (*4*). Among men who smoked (or formerly smoked) 20 or more cigatettes a day, the death rate of ex-cigarette smokers who had stopped for less than 1 year before

entry in the study was considerably higher than for current smokers, but for those stopping 5 years or longer the rate was considerably lower than for current smokers.

Obviously, the factors previously described make it difficult to evaluate the degree of benefit derived from giving up cigarette smoking, and even more difficult to determine whether giving up the habit results in a reduction in death rates soon after. To obtain an accurate answer to these questions it would be necessary: 1) to eliminate the bias introduced by the influence of health on smoking habits, and 2) to adjust for the fact that many recent ex-smokers return to the habit within 1 or 2 years. Unfortunately, we have no means of meeting these two specifications, but we have attempted to meet partially the first.

Table 8 shows age-standardized death rates per 100,000 person-years for men in age group 50–74 at the time they enrolled in the study: The first column shows the rates for all subjects regardless of state of health; the second column shows death rates for men who said they were "sick at present" or had a history of heart disease, stroke, high blood pressure, or cancer of the lung, buccal cavity, pharynx, larynx, or esophagus; the third column shows death rates for men who said they were not "sick at present" and did not report having had any of these diseases. For simplicity, we will refer to the latter two groups as the "ill health" and the "good health" groups. The following smoking classes are shown: 1) men who never smoked regularly, 2) men with a history of only pipe and cigar smoking divided into current smokers and ex-smokers, 3) men with a history of only cigarette smoking divided into current smokers and ex-smokers, and 4) men with a history of only cigarette smoking who smoked (or formerly smoked) 20 or more cigarettes per day divided into current smokers and

TABLE 8.—Age-standardized death rates. Men aged 50–74 at start of study

Smoking habits	All subjects	"Sick at present" or history of disease*	Not "sick at present," no history of disease
Never smoked regularly	1, 374	3, 222	1, 001
Pipe, cigar only:			
Ex-smokers	1, 832	4, 267	1, 115
Current smokers	1, 379	3, 087	1, 105
Cigarette only:			
Ex-smokers	2, 051	4, 355	1, 322
Current smokers	2, 558	5, 217	2, 050
Cigarette only, smoked 20+ cigarettes a day:			
Current smokers	2, 659	5, 268	2, 166
Ex-smokers (yr):			
Stopped <1	2, 995	5, 760	1, 938
Stopped 1–4	2, 715	5, 272	1, 735
Stopped 5–9	2, 047	4, 227	1, 256
Stopped 10+	1, 814	3, 958	1, 110

*Men who said they were "sick at present" or had a history of heart disease, stroke, high blood pressure, cancer of the lung, buccal cavity, pharynx, larynx, or esophagus.

ex-smokers, the latter being subdivided by the number of years between the time they gave up smoking and enrollment in the study.

First note the column labeled "all subjects." The ex-pipe and ex-cigar smokers had higher death rates than the current pipe and cigar smokers. The ex-cigarette smokers (as a total group) had lower death rates than the current ones, but former "20+ a day" cigarette smokers who had given up the habit less than 5 years before enrolling in the study had higher death rates than current "20+ a day" cigarette smokers. These same relationships were found among men in the "ill health" group as shown in the second column of the table.

Major interest here centers on the "good health" group shown in the third column of table 8. By eliminating the subjects most easily identified as in ill health at the start of the study, we have reduced the overweighting of ex-smokers with men who stopped smoking as a result of ill health. We now find the death rates of ex-pipe and ex-cigar smokers to be about the same as for current pipe and cigar smokers. Furthermore, the death rate of former "20+ a day" cigarette smokers who had given up the habit less than 1 year before enrolling in the study was lower than for current "20+ a day" cigarette smokers. The death rate of the former heavy cigarette smokers who had stopped 10 years or longer was only about 11 percent higher than that of men who never smoked regularly.

In making an analysis confined to men who were not "sick at present" and not reporting a history of certain serious diseases, we reduced, but certainly did not eliminate, the bias introduced by the influence of health on smoking habits. Furthermore, we were unable to adjust for the fact that some ex-cigarette smokers (particularly recent ones) returned to the habit soon after enrolling in the study. Even so, the recent ex-heavy cigarette smokers had somewhat lower death rates than current heavy cigarette smokers. This suggests that if both sources of bias could be entirely eliminated, death rates would decline rather rapidly soon after heavy cigarette smokers give up the habit.

SOME FURTHER PROBLEMS

Now let us look at some of the implications of these findings.

If we wish to obtain an estimate of death rates in relation to amount of cigarette smoking, we immediately have the problem of what to do with the ex-smokers. In a controlled experiment, we could avoid this difficulty if we denied the subjects the privilege of giving up smoking. However, such an experiment would be highly artificial, since it eliminates a factor vital to our understanding of the real problem. Remember we are dealing not simply with exposure to cigarette smoke but with the more complex problem of the *habit* of exposing one's self to cigarette smoke. Effects of this habit are the production of certain physical complaints (such as coughing and shortness of breath) and the production or accentuation of certain diseases and symptoms. Often because of

these complaints and diseases smoking is stopped, thereby further exposure to cigarette smoke is eliminated. In other words, we are dealing with a feedback mechanism, such that, in some instances, the duration of exposure to cigarette smoke is self-limiting.

Under these conditions, it seems irrelevant to ask the question:

> "What would be the effect of various amounts of cigarette smoking *if* smokers never gave up the habit and never changed their daily consumption of cigarettes?"

Presumably, if these conditions prevailed, the effects of the habit would be even worse than is actually the case. Since they do not prevail, then, in our opinion, it is more logical to ask a different question:

> "What are the effects of the habit of cigarette smoking in relation to the degree to which individuals have indulged in the habit up to a certain age?"

In a prospective epidemiological study, we might modify the question to read:

> "What are the later rates of morbidity and mortality among cigarette smokers in relation to their smoking habits up to the time of enrollment in the study?"

This is the question actually asked, and answered, in a number of prospective studies on smoking in relation to death rates. Usually, the ex-smokers are considered as a separate group, and the current smokers are classified by number of cigarettes smoked. For a more precise estimate, degree of inhalation and years of smoking (or age at start of smoking) should also be considered. However, for simplicity, let us only consider number of cigarettes smoked.

Amount of smoking might be estimated in terms of the total number of cigarettes smoked during the lifetime of the subject or of the maximum number smoked per day for a period of about 1 year. However, the most convenient index of amount of cigarette smoking is the number of cigarettes *currently* smoked per day at the time the subjects are enrolled in a study. It has the advantage that people can better answer questions on current habits than on past habits, particularly if their habits vary. In this study, the subjects were asked about their current cigarette smoking on two occasions. Table 9 shows the current amount of cigarette smoking they reported on the second questionnaire in relation to their report on the first one. It is confined to men between 50 and 59 who, on the first questionnaire, reported a history of only cigarette smoking. Daily consumption is divided into five categories: none or occasional; 1 to 9 cigarettes a day; 10 to 19 a day; 20 to 39 a day; and 40 or more a day.

Over half of the current cigarette smokers (at the time of the second questionnaire) were smoking approximately the same number of cigarettes a day as they reported smoking 2 years earlier. Furthermore (exclusive of those who quit smoking), most who increased or decreased their daily consumption changed only to the extent of moving into an adjacent amount category. For this reason, current daily consumption at the time

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TABLE 9.—Distribution of subjects by amount of cigarette smoking reported on second questionnaire in relation to amount on first one. Men aged 50–59 at enrollment who answered both questionnaires and on first reported history of cigarette only

Cigarette smoking reported on first questionnaire	Cigarette smoking reported on second questionnaire											
	Total		None or occasionally (ex-smoker)		1–9 a day		10–19 a day		20–39 a day		40+ a day	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Current smokers												
1–9 a day	4, 144	100. 0	877	21. 2	1, 956	47. 2	876	21. 1	401	9. 7	34	0. 8
10–19 a day	9, 133	100. 0	1, 001	11. 0	683	7. 5	4, 001	43. 8	3, 356	36. 7	92	1. 0
20–39 a day	31, 620	100. 0	2, 538	8. 0	507	1. 6	2 440	7. 7	23, 417	74. 1	2, 718	8. 6
40+ a day	7, 067	100. 0	463	6. 6	90	1. 3	104	1. 5	2, 163	30. 6	4, 247	60. 0
Ex-cigarette smokers	18, 291	100. 0	16, 735	91. 6	338	1. 8	386	2. 1	718	3. 9	114	0. 6
Total	70, 255	100. 0	21, 614	30. 7	3, 574	5. 1	7, 807	11. 1	30, 055	42. 8	7, 205	10. 3

of enrollment in a study is a reasonably good index for estimating death rates in relation to amount of cigarette smoking, but it is far from a perfect index, and we will now consider its imperfections.

Table 10 is the same as table 9 except that the subjects are divided into two groups according to whether they reported having heart disease, stroke, or high blood pressure during the period between the two questionnaires. Many men shifted from one amount category to another. The tendency to stop or decrease smoking was greater among those with heart disease, stroke, or high blood pressure, and the tendency to increase smoking was greater among men without these diseases. The tendency of ex-smokers to resume the habit was about the same in both groups. The net result of these changes is summarized in table 11.

First let us compare current smokers with ex-smokers. Of those classified as current smokers on the first questionnaire (1959–60), 3.7 percent had heart disease, stroke, or high blood pressure before answering the second; of those classified as current smokers on the second questionnaire (1961–62), only 3.0 percent had these diseases. A corresponding change in the opposite direction occurred among those classified as ex-smokers (*i.e.*, a change from 3.4 to 5.1%). Some implications of this have been discussed previously.

Now let us consider the four categories of current smokers. When the men are classified by their current habits as reported on the first questionnaire (1959–60), the percentage having heart disease, stroke, or high blood pressure during the *following* 2 years increased with amount of cigarette smoking. This reflects the influence of smoking on the occurrence of these diseases. In contrast, when the same men are classified by their current habits as reported on the second questionnaire (1960–61), the percentage having had heart disease, stroke, or high blood pressure during the *preceding* 2 years decreased with amount of cigarette smoking. This reflects the influence of health on changes in smoking habits.

The type of shifts occurring during this particular 2-year period almost certainly occurred during the 2-year period preceding the start of this study in 1959–60. Furthermore, it will be surprising if the same type of shifts did not again occur during the 2-year period following 1961–62. In other words, the *current* smoking habits of a group of men are highly influenced by their current and earlier state of health, and this would be true, regardless of the date specified as "current." The group of subjects classified as current light smokers are weighted with people in ill health who had previously been heavier smokers, but lacks former light smokers in ill health who became ex-smokers. As a net result, this group may perhaps be unweighted or slightly overweighted in one direction or the other. The group of subjects classified as current very heavy smokers are both: (*a*) weighted with people in good health who had previously been lighter smokers, and (*b*) underweighted with people in poor health who had previously been very heavy smokers but had become lighter smokers or ex-smokers. There being no compensating changes, the net result is that this group is underweighted with people in poor health.

STUDY OF CANCER AND OTHER CHRONIC DISEASES

TABLE 10.—Distribution of subjects by amount of cigarette smoking reported in second questionnaire in relation to amount on first one. Men aged 50–59 at enrollment who answered both questionnaires and on first reported history of cigarette only

Cigarette smoking reported on first questionnaire	Cigarette smoking reported on second questionnaire											
	Total		None or occasionally (ex-smoker)		1–9 a day		10–19 a day		20–39 a day		40+ a day	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Subjects who reported heart disease, stroke, or high blood pressure during period berween first and second questionnaires												
Current smokers												
1–9 a day	133	100.0	55	41.4	46	34.6	20	15.0	12	9.0	0	—
10–19 a day	329	100.0	100	30.4	33	10.0	108	32.8	85	25.8	3	0.9
20–39 a day	1,172	100.0	303	25.9	41	3.5	110	9.4	662	56.5	56	4.8
40+ a day	297	100.0	73	24.6	4	1.4	9	3.0	82	27.6	129	43.4
Ex-cigarette smokers	623	100.0	568	91.2	14	2.2	13	2.1	23	3.7	5	0.8
Total	2,554	100.0	1,099	43.0	138	5.4	260	10.2	864	33.8	193	7.6
Subjects who did *not* report heart disease, stroke, or high blood pressure during period between first and second questionnaires												
Current smokers												
1–9 a day	4,011	100.0	822	20.5	1,910	47.6	856	21.3	389	9.7	34	0.8
10–19 a day	8,804	100.0	901	10.2	650	7.4	3,893	44.2	3,271	37.2	89	1.0
20–39 a day	30,448	100.0	2,235	7.3	466	1.5	2,330	7.7	22,755	74.7	2,662	8.7
40+ a day	6,770	100.0	390	5.8	86	1.3	95	1.4	2,081	30.7	4,118	60.8
Ex-cigarette smokers	17,668	100.0	16,167	91.5	324	1.8	373	2.1	695	3.9	109	0.6
Total	67,701	100.0	20,515	30.3	3,436	5.1	7,547	11.1	29,191	43.1	7,012	10.4

Table 11.—Percent of men who had heart disease, stroke, or high blood pressure during period between two questionnaires by (*a*) cigarette smoking reported on first questionnaire and (*b*) that reported on second. Men aged 50–59 at enrollment*

Cigarettes per day	(a) First questionnaire: Total No. of men	With circulatory disease: Number	Percent	(b) Second questionnaire: Total No. of men	With circulatory disease: Number	Percent
Current smokers						
1–9 a day	4, 144	133	3. 2	3, 574	138	3. 9
10–19 a day	9, 133	329	3. 6	7, 807	260	3. 3
20–39 a day	31, 620	1, 172	3. 7	30, 055	864	2. 9
40+ a day	7, 067	297	4. 2	7, 205	193	2. 7
Total current	51, 964	1, 931	3. 7	48, 641	1, 455	3. 0
Ex-smokers	18, 291	623	3. 4	21, 614	1, 099	5. 1
Grand total	70, 255	2, 554	3. 6	70, 255	2, 554	3. 6

*Data confined to men who on first questionnaire reported a history of only cigarette smoking.

For the reasons outlined, an analysis of death rates by current amount of cigarette smoking may lead to an underestimate of the slope of the curve relating death rates and amount of cigarette smoking.

One other problem of special interest at the present time is the variation in nicotine and tar content of different brands of cigarettes now on the market. Several years ago, this fact was highly advertised and many cigarette smokers switched to low-nicotine, low-tar brands, hoping to avoid any ill effects without giving up cigarette smoking. To determine whether their hopes were justified, we asked cigarette smokers what brand they smoked. Later, we will study death rates of cigarette smokers in relation to the nicotine and tar content of the smoke. Unfortunately, we are faced with the difficulty that the tendency to switch from a high-nicotine to a low-nicotine brand is related to the state of health of the smoker.

Data in table 12 are confined to men who at the start of the study smoked cigarettes, the main-stream smoke of which contained 1.9 to 2.7 mg of nicotine and a comparably large amount of total tar. (These men had never smoked pipes or cigars regularly.) Relatively few of them switched to low-nicotine, low-tar brands within the next 2 years, probably because of a government order in 1960 banning the advertising of the tar and nicotine content of various brands of cigarettes. As shown in table 12, the percentage switching to low-nicotine, low-tar brands was greater among those who were hospitalized than among those who were not, and was greater among those reporting heart disease, stroke, or high blood pressure than among those not reporting these diseases. This influence of health on smoking habits introduces a serious difficulty if we attempt to determine the relationship (if any) between death rates and the nicotine and tar content of cigarettes smoked. If nicotine and tar content has no influence on death rates then, because of this factor,

death rates will almost certainly be highest among cigarette smokers who smoke brands containing the least amount of nicotine. The reverse will be true only if the benefit of switching to low-nicotine, low-tar brands is so great as to outweight the effect of ill health on the tendency to switch brands.

TABLE 12.—Distribution of cigarette smokers by nicotine content of cigarettes smoked at time of second questionnaire. Men aged 45–69 who at enrollment smoked cigarettes containing 1.9 to 2.7 mg of nicotine and who never smoked pipes or cigars regularly

Hospitalization and circulatory disease reported after Oct. 1, 1959	Nicotine content (mg) of cigarettes smoked at time of second questionnaire							
	Total		1.9–2.7		1.2–1.8		0.4–1.1	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Hospitalized								
Yes	6, 163	100. 0	5, 381	87. 3	612	9. 9	170	2. 8
No	32, 104	100. 0	28, 498	88. 8	2, 995	9. 3	611	1. 9
Heart disease, stroke, or high blood pressure								
Yes	1, 134	100. 0	972	85. 7	120	10. 6	42	3. 7
No	37, 133	100. 0	32, 907	88. 6	3, 487	9. 4	739	2. 0

SUMMARY

An analysis has been made of smoking habits in relation to the health of men enrolled in a prospective study in 1959–60 by volunteer workers of the American Cancer Society. All of them answered detailed questionnaires at the time of enrollment and a large percentage of the survivors answered brief questionnaires about 2 years later. They have now been traced for approximately 4 years.

It was found that ill health often results in a smoker either giving up the habit or reducing his daily consumption. This has an influence on the later death rates of men designated as "ex-smokers" and men designated as "current smokers" of various amounts of tobacco.

There is some tendency for cigarette smokers in poor health to switch to brands containing a low amount of nicotine and tar. Cigarette smokers who have switched from high-nicotine, high-tar cigarettes to low-nicotine, low-tar cigarettes are weighted with persons in poor health. For this reason, it will be difficult to determine whether making such a switch is beneficial from the standpoint of reducing death rates.

It is suggested that difficulties of this type may occur in epidemiological studies of various other factors (*e.g.*, diet, exercise, and sleep) which may have an effect on health and may also be influenced by state of health.

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Studies of Disease Among Migrants and Native Populations in Great Britain, Norway, and the United States. I. Background and Design[1]

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INTERNATIONAL contrasts in mortality experience have long excited interest and speculation. The relatively high death rate from cerebrovascular disorders in Japan, the apparently low rate from arteriosclerotic heart disease in Japan and France (*1*), and the disparity in breast cancer incidence between the Netherlands and England and Wales (*2*) are typical examples. There have been doubts, however, about the effect of differences in diagnostic habits and methods of disease classification and coding on the vital statistics of many countries. Sometimes, special schemes of cancer registration based on pathological evidence have confirmed international trends, as for cancer of the lung (*3*), but no such scheme exists for the registration of cases of other types of cardiorespiratory disease. Nevertheless, the large differences in death rates from such disorders between countries as alike as Great Britain, Norway, and the United States cannot be ignored. If these reports reflect major differences in disease experience, then a search for the underlying reasons could give new leads to the causes and prevention of the diseases concerned (*4*).

The major contrasts in cardiorespiratory death rates appear, especially in males, in the age group 45 to 64. Table 1 shows a marked excess in arteriosclerotic heart disease among U.S. white males over the rate for their British contemporaries, though the latter have much higher death rates for both malignant and nonspecific disorders of the lung. Overall, however, the total U.S. mortality in this age group is slightly above the British level. On the other hand, within each category of cardiorespiratory disease the Norwegian rates are consistently the lowest of the three, and the death rate from all causes is well below that of the other two. Among women, there also exist differences similar in direction but of lesser degree. A more detailed analysis suggests that diagnostic transfer—although it clearly occurs, *e.g.*, between "emphysema" and "chronic bronchitis"—is not numerically important enough to account for the broad

[1]Supported in part by the Public Health Service research grant HE-04775 from the National Institutes of Health.

excesses in cardiovascular disease among Americans or respiratory disease among the British.

TABLE 1.—Mortality rates for cardiorespiratory diseases in Norway, Great Britain, and the United States (average annual rate per 100,000 population aged 45–64)

	NORWAY (1960–62)	GREAT BRITAIN (1960–62)	UNITED STATES (1959–61)
MALES			
All causes	967.6§	1,393.8	1,423.2
Coronary heart disease*	308.3	414.3	583.5
Lung cancer†	39.0§	180.1	84.7
Chronic nonspecific lung disease‡	9.8	115.6	22.2
FEMALES			
All causes	553.3§	750.9	687.0
Coronary heart disease*	74.1	114.9	151.8
Lung cancer†	6.6§	23.5	11.4
Chronic nonspecific lung disease‡	3.0	21.1	3.6

*ISC codes 420, 422.

†ISC codes 162.1, 163 for Great Britain and the United States; ISC codes 162, 163 for Norway.

‡ISC codes 502, 526, 527.1 for England and Wales and the United States; ISC codes 502, 526, 527 for Norway and Scotland (component of rate for Great Britain).

§1961.

Consideration of such data led Dr. James Watt, then Director of the National Heart Institute, Bethesda, Maryland, to suggest that the Advisory Council should set up a Joint United States-United Kingdom Board on Cardiorespiratory Disease to study the reality of, and possible causes for, the different adverse experience of both American and British males in middle life compared with Norwegian men of the same age. The possibility of divergent diagnostic conventions was implicit in the vital statistical data. The American members of the Board therefore toured British hospitals, seeing and discussing patients suffering from various types of cardiorespiratory disorders. They reported (*5*) that there certainly were differences in diagnostic terminology in relation to the chronic nonspecific lung diseases. Thus the "chronic bronchitis" of British parlance might be described as "bronchiectasis" with or without emphysema by American clinicians. Nevertheless, when all such alternative labels are grouped together the British excess of severe, disabling disease of this kind appeared unchallenged. On the other hand, apart from cor pulmonale, there seemed less discrepancy in the diagnosis of cardiovascular disease and thus no reason to suppose that the reported American excess in ischemic heart disease death rates was entirely a diagnostic artifact. Similar conclusions were derived from another study in which the same clinical data on a series of patients, dying as a result of various cardiorespiratory diseases, were used in turn by groups of American, British, and Norwegian hospital physicians as the basis of "death certification" (*6*). Despite national diagnostic idiosyncrasies, the broad distribution of deaths by major classes remained the same for the three groups.

Meanwhile, in the United States, studies of vital statistical returns were uncovering the growing threat to public health of chronic nonspecific lung disease. The importance of arteriosclerotic heart disease, hypertension, and associated vascular disorders was well recognized. But the arbitrary coding of only the underlying cause of death, indicated by the physician in death certificates, had minimized the importance of diseases, such as emphysema, which often appeared on the certificate only as contributory or associated causes (*7*). Until multiple-cause coding comes into general use, no very precise estimate can be made of the number of deaths in which chronic lung disease plays some part in the various countries in this study. When various diagnostic categories, such as "asthma," "bronchitis," "emphysema," and "bronchiectasis," were counted together in one group of "chronic respiratory disease" (*8*), it was possible to show that in the United States during the past decade such disorders were rapidly becoming more frequent and now approached lung cancer and surpassed tuberculosis as a risk to life.

CURRENT FIELD SURVEYS

These preliminary investigations showed the need for standardization of diagnostic terminology if effective international communication and comparison of disease experience, particularly in the field of cardiorespiratory disorder, were to be achieved. Further, if surveys of cardiorespiratory disease prevalence in the three countries were to be undertaken, the techniques of clinical assessment had to be rigorously standardized. Fortunately, the British Medical Research Council Committee on the Aetiology of Chronic Bronchitis had developed a questionnaire designed to elicit in a uniform fashion the symptomatic history of chronic respiratory disorder (*9*), while at the London School of Hygiene and Tropical Medicine, a similar questionnaire on symptoms of circulatory disease had been evolved and tested (*10*). These questionnaires have been approved by the World Health Organization for use in international surveys. In the same way, the use of other procedures, such as electrocardiography and sphygmomanometry, were standardized by the use of codes based on the objective measurements of the trace (*11*), or by the development of a special sphygmomanometer designed to eliminate some sources of observer variation (*12*). These and other methods for eliciting and tabulating data in a uniform manner have been described (*13, 14*).

These standardized methods have been used in a number of surveys of respiratory and cardiovascular disorder in the three countries involved in the present comparison. One group of such studies entailed the survey of cardiorespiratory symptoms and function in men doing similar jobs, *e.g.*, driving service vehicles or buses but in different environments in Britain, Norway, and the United States (*15–17*). Another approach compared the results of a whole population survey in the small New England town of Berlin, New Hampshire, with the nation-wide survey carried

out by the British College of General Practitioners (*18*). These surveys all suggest that there are real differences in the pattern of respiratory morbidity between urban and rural British samples and between the groups in British cities, such as London, and those examined either in Bergen, Norway, or in the United States, in Berlin, New Hampshire, Westchester Co., N.Y., Baltimore, Maryland, and Washington, D.C. Generally, within the same smoking group, the British urban male suffers more often, and at an earlier age, from chronic bronchitis, with winter cough and persistent sputum production, repeated chest illness, and lowered lung function than either his rural compatriot or his urban contemporary in Norway and the United States. Preliminary indications from the cardiovascular aspects of some of these studies are that American drivers have more complaints of chest pain suggestive of myocardial infarction, more frequent electrocardiographic abnormalities, and a higher mean blood pressure (*19*).

Such surveys can emphasize the reality of the international difference in disease experience suggested by mortality statistics. They at least establish a *prima facie* case for further investigation. They have limitations, however, in that they are restricted in scope and scale. Thus it may be difficult to make inferences about national experience on the basis of the samples used, while the relatively small numbers involved handicap any detailed analysis, *e.g.*, by smoking habits and social class distribution in the various countries concerned. Further, while prevalence data can give useful clues to possible causes of international differences, they show the picture at only one point in time and give little information about the sequence of events leading to the present position. Yet there are indications that the severe cardiorespiratory disease seen in middle life is the end result of exposure to an environmental background or to personal habits that began to have an effect even in childhood. In studies of the natural history of chronic bronchitis and emphysema in middle-aged invalids, for example, the excessive frequency of repeated chest illnesses dates back to early adult life (*20*). In British Army recruits, serious respiratory illness rates depend more on the area in which the man presumably spent his early life than on the area in which he was serving at the time of his illness (*21*). A survey of 11-year-old schoolchildren in the British steel town of Sheffield (*22*) showed that, compared with children of the same age in rural Wales, they had more serious infections, such as chronic suppurative otitis media and bronchitis or pneumonia, and that, in the polluted atmosphere of the industrial city, attacks of the latter seemed to cause a greater depression of lung function.

MORTALITY STUDIES

Perhaps the most intriguing evidence of the possible serious, long-term effects of exposure to adverse environmental conditions in youth is from observations on the lung cancer death rates among British migrants in

New Zealand (*23*), South Africa (*24*), Australia (*25*), and the United States (*26*). Quite consistently, such studies have shown that the male from the United Kingdom experiences death rates from lung cancer above those of his contemporaries in his land of adoption and below those in the home country, and this excess over the prevailing rates in the new country cannot be explained by the number of cigarettes smoked (*26*). These various findings seem to imply that for both malignant and nonmalignant disease of the lung, exposure to some factor or factors in the British environment in early life, perhaps air pollution, predisposes to the later development of the more serious forms of respiratory disease.

Little has been done along these lines with respect to cardiovascular disease. It may be that the cardiovascular results of early experience might be demonstrated equally well by studies of migrant populations coming from different backgrounds and living in the same environment in the new country. For these reasons, the Joint United States-United Kingdom Board recommended to the National Heart Institute that studies of the cardiorespiratory disease experience of British and Norwegian migrants living in the United States should be undertaken. The practical realization of this proposal, however, was effected only by Dorn's appreciation of the unique opportunity afforded by the 1960 Census of identifying British and Norwegian migrants now living in the United States. Dorn also recognized that the facilities of the Bureau of the Census could be used to obtain wide-scale information, not included in the Census schedules, relevant to the risk of cardiorespiratory disease. Finally, on the basis of his own experience and that of his colleagues in the U.S. Public Health Service, he suggested how deaths among British and Norwegian migrants could be identified and ancillary data obtained from the next-of-kin. These ideas made implementation of the present study practicable.

STUDIES OF MIGRANT POPULATIONS

Sir William Hamer (*27*) early pointed out the value of studying groups who had migrated from country districts to urban areas during the period of industrial development in England in the nineteenth century. The unique opportunity presented by the massive migrations in the last 100 years from the Old World to the New was utilized by Lombard and Doering (*28*) in the field of cancer and by Øedegaard (*29*) and Malzberg (*30*) in mental disease. Lombard and Doering were the first to show that the site distribution of cancer was related to the ethnic group to which migrants belonged. Haenszel (*26*) has confirmed Mancuso and Coulter's earlier finding (*31*) of an excess of lung disease among Polish and Russian immigrants of both sexes and among Mexicans, as noted by Steiner (*32*) and Buechley *et al.* (*33*).

The migration of human populations is certainly a grand-scale natural experiment, but it lacks the essential feature of rigorous experiment in that allocation to migrant groups is never strictly random. Selection—

either the self-selection, perhaps of the young and fit or of the unstable, or the purposive imposition of medical standards of fitness for entry—is inevitable. Migrants may differ from the populations from which they came or to which they go in many characteristics relevant to health, such as smoking habits, job, or social class, and they may move into areas where conditions are relatively poor. The interpretation of mortality statistics classified by place of birth is necessarily limited by the lack of detailed information on these secondary characteristics. Thus Stamler *et al.* (*34*) demonstrated that foreign-born groups living in Chicago have cardiovascular death rates, particularly from coronary heart disease, lower than the native-born but still well above those in their country of origin. The limited data available suggested that the two groups did not differ markedly in respect to current diet pattern and levels of blood pressure and cholesterol. The authors inferred that though the mortality differences reflected some residual characteristics related to their country of birth, the effect of life in America was of greater importance.

The review of previous studies of migrant populations indicated that a satisfactory interpretative analysis requires the collection of a wide range of detailed information about the residential history, social and occupational background, and personal habits, such as smoking, etc. At the same time it became evident that, for reasons of scientific profit and economy of effort, the scope of any study of migrant population should be extended to cover more than one migrant group and more than cardiorespiratory disease alone. Haenszel's work clearly demonstrated the potential of such studies for malignant disease. At his suggestion, the U.S. National Cancer Institute therefore elected to participate. That the Norwegian Cancer Registry was already engaged in collaborative studies with the group from the London School of Hygiene and Tropical Medicine and the National Cancer Institute was a fortunate coincidence, which made the choice of Norwegians as the second migrant population to be studied particularly appropriate.

INVESTIGATIVE METHODS IN MIGRANT STUDIES

Previous work on the disease experience of migrants has usually concentrated on the comparisons of death rates in these groups with those of their contemporaries in either the land of their origin or adoption. It now seems certain that a more comprehensive approach is both feasible and essential. Death certification data, for example, can be supplemented by morbidity information collected uniformly from migrant and native-born groups. At the same time, data on relevant personal habits and circumstances—such as smoking, exercise, or occupation—can be elicited and used to assess the contribution made by such personal factors to any disparity in disease prevalence between migrants and hosts.

The disease experience of migrants is also likely to be affected by their familial background, whether genetic or environmental. For this reason,

the disease experience of the siblings of migrants who have remained in their native country can provide information on the morbid results of different environments in later life on individuals from the same family background. It is also likely that the health of the migrant is affected by the general environmental circumstances of the area of his current residence and, perhaps, of his place of origin. Evidence on this point can be derived from two sources: 1) the disease rate in the general population in the locality of past or present residence; 2) the areas of residence before or after migration can be characterized in such terms as population density, air pollution levels, and social indexes, *e.g.*, infant mortality, etc. The morbidity or mortality of the migrants can then be analyzed in relation to the place of origin or current residence.

Finally, the measurement of morbid risks at differing periods after migration could show whether increasing exposure to conditions in the new country was lowering the disease rate of chronic nonspecific lung disease among British immigrants or steadily increasing the rate for ischemic heart disease among Norwegians. Conversely, of course, observations on disease rates among migrants exposed, for example, to British urban conditions for varying periods, before migration, might show the length of such exposure required to produce an indelible effect on subsequent experience from the chronic bronchitis-emphysema group of diseases. Thus, detailed histories are required from this wide range of contrasted groups to decide whether the postulated specific "national" or "local" effects on the various forms of cardiorespiratory disease indeed existed, how these effects waxed and waned in relation to migration history, and finally to indicate more precisely the mechanism of the effects in terms of personal habits, social circumstances, and occupational history.

METHOD OF CONDUCT OF STUDY

A detailed description of the various technical procedures used will be given in the account of each phase of the inquiry. It is enough now to outline the general investigative plan and how data are collected and analyzed.

SPECIFIC AIMS OF THE STUDY

The primary objectives of the study are: 1) to determine the relative frequency of morbidity and mortality, especially from various forms of cardiorespiratory disorder, among British and Norwegian migrants in the United States, their siblings still living in their native countries, and the native-born populations living in those areas in which the migrants lived either before or after migration; 2) to relate the disease experience of these groups to both personal factors, such as smoking and occupation, and general factors, such as air-pollution levels in the area of residence; 3) to establish time relationships between disease experience and date of migra-

tion, changes in habits, or occupation; and 4) to identify possible explanations for the major differences in national death rates, initially, in the various forms of malignant and nonmalignant diseases of heart and chest and, perhaps subsequently, in cancer of the stomach and other conditions.

METHODS

The 1960 U.S. Census returns for a 25 percent sample gave the names and addresses of some 200,000 persons born in England and Wales and Scotland and about 50,000 Norwegian-born now living in the United States. A probability sample of these individuals was drawn and to them was posted a questionnaire designed to elicit basic information, *e.g.*, about their birth place, date of migration, personal habits, and occupational history before and after migration. This part of the inquiry was intended to establish a comprehensive description of the British and Norwegian migrant populations in the United States. This provides estimates, divided according to habits and background, of the migrant populations exposed to risk.

The numerator of the mortality rates for the migrant populations in the United States is provided by the deaths occurring among British and Norwegian migrants during 1963–64 inclusive for the British and 1963–65 for the Norwegians. During these periods, all deaths among those whose certificates indicated their country of birth as either of these two countries were identified at the National Center for Health Statistics and noted for further query. The next of kin were asked to complete a questionnaire, giving as many of the same details found in the form for the sample as were likely to be known to members of the same family. Some of these deaths occurred among those included in the probability sample, and this provided a check on the consistency of information obtained by postal inquiry during life from the individual himself and that given after his death by his relatives. The certifying physicians were asked by letter to amplify the diagnostic information on the cause of death given by them on the death certificates.

Although the main emphasis in this inquiry is on mortality data, an attempt was also made to elicit histories of current cardiorespiratory morbidity among those in the probability sample. Some of the crucial questions of the British respiratory and cardiovascular questionnaires mentioned were included in the first questionnaires sent out to those in the probability sample. To persons giving positive answers to one or more of these questions and to a random sample of those answering negatively, a second questionnaire was posted. This consisted essentially of an amalgam of the two British questionnaires together with questions on changes in symptoms after migration and additional data on previous medical history. The responses to these questions could then be classified, according to recognized conventions, into clinical groupings, labeled as "chronic bronchitis," "angina," etc. The identification of "cases" in this

way allowed symptom prevalence rates to be computed as in the mortality tabulations.

It must be pointed out that when this study was designed and conducted there were no reports on large-scale symptomatic case finding by postal questionnaires on cardiorespiratory disorder. On the other hand, experience with the respiratory and cardiovascular questionnaires suggested that, when used in clinical or field-survey interviews, both were valid since they correlated quite well with more objective measures, *e.g.*, of respiratory disturbance such as sputum production or lung function tests (*35*) or of electrocardiographic evidence of ischemia (*36*). Follow-up experience also implied that the cardiovascular questionnaire, for example, certainly picked out a group with a high risk of later admission to hospitals or death from cardiac infarction (*36*). Meanwhile, Cederlof and his colleagues in Sweden (*37*) have used similar postal questionnaires in their twin study and found them practical and informative. Because a follow-up on subsequent mortality experience also provides a built-in validation, it was decided to use this method of cardiorespiratory morbidity measurement in the first phase of the study. The wide geographic dispersion of the samples surveyed precluded any ready validation of the questionnaires by clinical review by teams in the three countries. The expectation was that other surveys, currently in progress on different populations in these three countries, would give some indication of the consistency of the relationship between self-administered questionnaire responses and physical findings among British, Norwegians, and Americans.

Similar postal inquiries were made to a random subsample of the native-born sample of the U.S. population. Both British and Norwegian migrants were also asked to give the names and addresses of any brothers and sisters still living in their country of origin. The replies were sent back to the countries, where addresses were checked and questionnaires sent to all who could be traced. Finally, questionnaires were sent to random samples of the British and Norwegian populations requesting the basic information obtained in the two questionnaires used in the United States; except for the pilot stage, only a single questionnaire was used in the surveys of both the sibling and random sample groups in Britain and Norway.

PROGRAM OF DATA ANALYSIS

The successive stages of the analysis of the data collected in the manner described follow the same time sequence as the phases of the study itself.

1) Symptom prevalence data collected from samples of the British and Norwegian migrants and the native-born American population are to be handled thus:

(*a*) The frequency of designated syndromes—"persistent cough and phlegm," "chronic bronchitis," "angina," and "possible infarction"—is

being related in each sample to the major variables: sex, age, and smoking habits. After standardization, accounting for these variables, the prevalence rates in the three groups are compared. Then, within each migrant group, comparisons are made between individuals grouped, *e.g.*, according to their age at migration or degree of urbanization of place of origin.

(*b*) Cross-tabulations within each sample are planned to identify any consistently present relationship between the defined syndromes and secondary factors such as occupation and social class, exercise habits, and physique.

(*c*) The behavior of these relationships in different national groups is to be explored. Thus, a comparison of the gradient of respiratory symptoms with increased cigarette smoking among urban and rural Americans or between siblings living in urban England and urban America might detect interaction between smoking and the effect of different degrees of exposure to urban air pollution.

(*d*) The pattern of cause-specific symptom prevalence rates will be compared with available corresponding mortality rates, *e.g.*, foreign-born groups in the United States to determine the degree of consistency between results based on such vital statistics on mortality and those from symptom surveys.

(*e*) Morbidity levels among migrants from, or present inhabitants of, specific areas, as estimated from the postal surveys, are to be compared with available mortality and mobidity rates for these areas such as those resulting from the British Ministry of Pensions and National Insurance survey of sickness-absence in the United Kingdom. Such comparisons will be extended to consider the relation, if any, between these area morbidity rates and the environmental characteristics such as local levels of air pollution.

2) The program of analysis for the mortality data follows the same pattern. The coding of data on the death certificate and ancillary certifier's report follows conventional practice in assigning the underlying cause of death. But in view of the possible effect of different assignment practices between physicians, especially when pulmonary and cardiac disorders coexist, a scheme of multiple-cause coding based on that used by Dorn in his smoking study (*38*) is also to be employed.

Much the same type of analysis is planned for the comparison of migrant populations with the random samples of the populations from which they came. But more detailed within-family analyses are needed for the comparison of migrants with their siblings in the home country.

FOLLOW-UP PROCEDURES

A continued monitoring of deaths among the British and Norwegian-born migrants in the United States will, as already noted, provide an

automatic follow-up on all deaths occurring among those in the migrant samples. Unfortunately, no similar follow-up on the U.S. random sample is readily practicable. Similar monitoring arrangements in Britain and Norway will, however, give information on all deaths in both the sibling group and the national sample in these two countries. In the short run, the detailed analysis of information on these deaths will act as an essential check on the validity and prognostic value of the morbidity questionnaire. In the longer run, however, it will identify any differences in the natural history or the rate of evolution from symptoms to terminal illness of cardiorespiratory disorders in the differing circumstances of life to which the various samples are exposed. Moreover, as experience accumulates, more data on other diseases such as cancer of the stomach and on less common conditions will become available for analysis.

Obviously, the variety and number of observations accruing from this study can be handled in many ways that give evidence on a wide range of questions. Some, such as the difference in the social distribution of gastric cancer arising during the follow-up in migrant and sibling groups, will extend beyond the field of cardiorespiratory disease. Others, such as the geographic and social distribution of British and Norwegian migrants in the United States, are of sociological rather than medical interest. This outline of the evolution of the research plan can only indicate the possibilities. It is designed simply to give a broad conspectus of materials and method and an introduction to the series of papers that follow.

SUMMARY

This paper summarizes the historical evolution, objectives, and methods of a study of cardiorespiratory and other disease experience among residents of the United States born there, in Britain, or Norway. This experience is to be compared with that of siblings of British and Norwegian migrants still living in their native countries and of representative samples of the adult populations of these two countries. A postal inquiry on the prevalence of defined cardiorespiratory syndromes and on personal habits, occupational and residential histories will be followed by a longer term study involving the collection of similar data from a sample of deaths occurring in these various British and Norwegian populations.

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Studies of Disease Among Migrants and Native Populations in Great Britain, Norway, and the United States. II. Conduct of Field Work in the United States [1]

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EARLY in 1961, Dr. Harold Dorn began exploratory discussions with representatives of the Bureau of the Census concerning the possible participation of the Bureau in an international collaborative study of chronic respiratory and heart disease among persons of British and Norwegian origin. The Bureau conducts a wide range of surveys, including a number in the field of health. Best known of these is the continuous series of surveys, blanketed under the National Health Survey, which the Bureau operates under contract for the National Center for Health Statistics of the U.S. Public Health Service. Other more limited undertakings, often coordinated with the Bureau's monthly Current Population Survey, have explored such topics as smoking habits of the population, health insurance coverage of the elderly, and incidence of disabling illness.

The problem posed by Dorn, however, represented a departure from the Bureau's previous work in the health field and was, therefore, a welcome opportunity for additional experience in, and insights into, this crucial area of statistics. The large scale of the program and the various stages of investigation planned almost dictated in the interest of economy that the initial inquiries be made by mail. The previous health surveys of the Bureau, on the other hand, had been conducted mainly by personal interviews. More important, the approach proposed for the measurement of morbidity—through questions on the incidence and severity of symptoms of various kinds—differed significantly from the procedure used in the National Health Survey, where detailed inquiries are made about specific chronic diseases and physical impairments.

A number of challenging sampling problems were also raised by Dorn's proposal. The desired population for the U.S. portion of the program, as described by Reid (*1*), were British and Norwegian migrants of specified ages. Since these migrant groups represent a minute fraction of the population, their identification through the usual area-sampling methods would have been highly inefficient. Fortunately, the Bureau has at its

[1] Supported in part by the Public Health Service research grant HE-04775 from the National Institutes of Health.

disposal for sampling purposes another major resource—the 1960 Census of Population. For a 25 percent sample of the entire population, the 1960 Census gathered a wide range of detailed information including a crucial (for this purpose) item—place of birth. With the very limited rate of recent immigration from these two countries, it was believed that the population, as represented in the most recent census, would be entirely satisfactory for this program. Another objective was to develop an optimum sample design assuring coverage of the largest part of the population within a relatively restricted number of areas, to limit the problems and expense in later stages of the program, such as follow-up interviews, collection of mortality records, and possible arrangements for physical examinations. Based on this decision, the sample was restricted to 12 States containing some 75 percent of the British and 80 percent of the Norwegian population. An additional 5 States were provisionally added for the Norwegian sample, but were later deleted when it was determined that the problems arising from geographic distribution outweighed the advantages of a slightly larger sample.

The program also required the selection of a sample of U.S.-born white persons of comparable age to be used as a contrast in appraisal of the morbidity rates of the migrants. A solution, which presented some further research possibilities, was the use, with the cooperation of the National Center for Health Statistics, of the appropriate geographic components of a representative national sample previously interviewed in the National Health Survey (NHS). At a later stage, chronic conditions as identified by the symptomatic approach (the present study) will be compared with the incidence of these conditions as measured by the traditional NHS method.

Based on the initial proposals developed with the Bureau by Dorn and his associates, a pretest was initiated in July 1962, to explore problems of questionnaire design and content, respondent cooperation, difficulties in locating sample cases (the addresses of selected cases obtained from the Census were 2 years old by that time), and related matters. The favorable experience in the pretest convinced all parties that the project, with appropriate modifications, was feasible and the Bureau agreed to undertake the field work with financial support from the National Institutes of Health. Under these arrangements, the Bureau assumed responsibility for the following steps:

1) Design and selection of the samples of British and Norwegian migrants and the U.S.-born sample.
2) Mailing two stages of questionnaires (developed and tested in cooperation with the sponsor) to each selected sample. The first-stage questionnaire collected background information and identified certain symptoms suggestive of cardiovascular or respiratory disorders. For migrants, it also secured names and addresses of siblings still living in the native country, to be used as one of the samples for the survey work to be done abroad. The second-stage questionnaire secured

considerably more detail on symptoms from those answering questions relating to them affirmatively in the first inquiry.

3) Field follow-up of appropriate subsamples of nonrespondents to the mail questionnaires to reduce, or at least to provide a measure of, any biases arising from that source.
4) Coding and processing the questionnaires and preparing punched cards. Other materials needed for tabulation and analysis, such as selected personal and socioeconomic characteristics of the sample persons based on 1960 Census and NHS questionnaires, were provided.
5) Preparation of certain detailed tabulations of 1960 Census data for the two ethnic groups.

The remainder of this paper is devoted to a more detailed description of various Census Bureau activities in connection with the study.

SAMPLE DESIGN

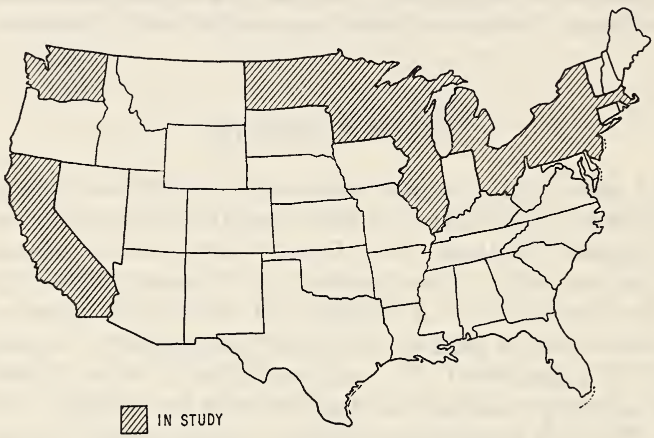
As noted earlier, three samples were used in the data collection for this program in the United States, the first consisting of migrants from Great Britain (England, Scotland, and Wales), the second of migrants from Norway, and the third, for comparison, of U.S.-born white citizens.

Since the present total of British and Norwegian migrants in the United States—around 800,000 and 150,000, respectively—represents only about half of 1 percent of the total population, a more efficient means than area-sampling methods was clearly needed for selection of the study samples. The only reasonably complete, current source of identification of migrants was the 1960 Census of Population, which obtained information on place of birth for a 25 percent sample of the entire population. Although some immigration has occurred since the Census (some 50,000 British and 5,000 Norwegians), most of the recent arrivals are young persons (including many brides of U.S. servicemen) not of immediate concern from the standpoint of a study of chest and heart disease in later life.

For the U.S.-born sample, many potential sources existed. Because of the possible value of related background data, a subsample of a national probability sample, previously used for the household interview part of the NHS program, was chosen.

Originally, the target sample size was approximately 30,000 persons for each of the three groups. However, because of technical and budgetary considerations, it was necessary to place a number of restrictions on the population to be sampled. Consequently, the sample size was reduced to around 20,000 each for the Norwegians and the U.S.-native-born group. The number of British migrants indentified in the 25 percent Census migrant sample was sufficiently large so that 30,000 cases could be selected, regardless of the restrictions imposed. This was not true of the much smaller Norwegian population nor of the U.S.-native-born drawn from a less than 1 percent national NHS sample.

The first restriction imposed on the sample design was one of geographic distribution, since later stages of the program contemplated the conduct of various follow-up activities, including the possibility of medical examinations for a subsample of the persons and for a long-term follow-up of mortality records. Close to 75 percent of the British migrants were located in 12 States,[2] and the corresponding proportion for Norwegians exceeded 90 percent in the same 12 States plus 5 selected provisionally but later dropped from the sample.[3] With so extensive a coverage, it was concluded that useful results could be obtained if the samples were confined to these States. For comparability, the U.S.-born sample was also restricted to the same 12 States (text-fig. 1).



Text-figure 1.—Geographic distribution of States included in study.

A second restriction was on the age range, which was initially set at 35–74 years for males and 30–74 years for females as of the time of the Census (or original interview for the NHS sample).[4] Younger persons were excluded because of low incidence of chronic disease in general and because the symptoms of the diseases under study are not generally present early in life. Very elderly persons were omitted because of the anticipated difficulty in the eduction of clear histories of chest and heart symptoms from them. Inmates of penal or mental institutions at the time of the Census or NHS interview were also excluded.

Certain special aspects of the three separate samples are described:

British sample.—Within each of the 12 States designated for the British and Norwegian samples, a 2-stage procedure was followed, involving first a selection of counties, to reduce further the labor of follow-up in later stages of the program. Counties were selected with certain joint proba-

[2] California, Illinois, Massachusetts, Michigan, Minnesota, New Jersey, New York, North Dakota, Ohio, Pennsylvania, Washington, and Wisconsin.

[3] The 5 States selected provisionally for Norwegian migrants only were Florida, Iowa, Montana, Oregon, and South Dakota.

[4] For Norwegians, the upper-age limit was later reduced to 72 years because of low response rates for older persons in pretest results.

bilities for the two classes of migrants to minimize the number of sample areas. The objective was to draw a sample which, appropriately weighted, was representative of all migrants of the specified ages in the 12 States. To eliminate areas with negligible numbers, all counties with fewer than 50 British migrants of the specified ages in the 25 percent Census sample were excluded from the British sample. This exclusion amounted to about 5 percent of the British migrants in the designated States, the majority of whom were rural residents. In contrast, all countries with 400 or more British or with 50 to 399 British and 50 or more Norwegians, a total of 80 counties in all, were automatically selected. From counties between these limits (those with 50-399 British but fewer than 50 Norwegians), a subsample of 1 in 3, or an additional 42 counties, was selected.

In the choice of the roster of persons to be queried, a subsample of 1 per 2.5 British males and 1 per 3.5 British females was designated in each of the 80 sample counties with the larger migrant populations. All British migrants of the specified ages were selected in the 42 smaller sample counties.

Norwegian sample.—The procedure was generally similar to that for the British sample, but lower limits were established because of the smaller population available for study. Excluded entirely from the Norwegian sample were counties with fewer than 10 Norwegians of the specified ages in the 25 percent Census sample (containing about 5% of the members in the original sample). Automatically selected, on the other hand, were a total of 109 counties with 50 or more Norwegians or with 10 to 49 Norwegians and 400 or more British. A one-third subsample, selected from counties with 10 to 49 Norwegians but fewer than 400 British, resulted in a total of 65 sample counties of this type. Within the selected counties, whether of the larger or smaller type, all Norwegian migrants of the specified ages were included.

Table 1 summarizes the first stage of sample selection for British and Norwegian migrants in the 12 States.

TABLE 1.—First stage of migrant sample selection: number of countries by number of migrants

Number of British (25% sample)	Number of Norwegians (25% sample)								
	0–9			10–49			50 or more		
	Total countries	In British sample	In Norwegian sample	Total countries	In British sample	In Norwegian sample	Total countries	In British sample	In Norwegian sample
0–49	366	—	—	138	—	47	33	—	33
50–399	71	24	—	53	18	18	19	19	19
400+	4	4	—	16	16	16	41	41	41

U.S.-born sample.—Of the 500 areas included in the NHS sample made available for this study, 200 were located in the 12 States covered in the migrant samples. Within these 200 areas, all white persons of the

specified ages who had been interviewed at the time of the original health survey (between July 1961 and June 1962) were selected. The NHS sample is a multistage national probability sample which has been described in detail elsewhere (*2*).

DATA COLLECTION

Following a pretest of the proposed procedures and survey instruments, two stages of data collection were carried out for each of the three samples. First, there was a mail questionnaire (Appendix A) which obtained information on a number of background variables and also screened for symptoms suggestive of cardiorespiratory disorders. Second, a more detailed mail questionnaire (Appendix B) was used to obtain more detailed information on symptoms and related topics. The two stages were conducted several months apart. The details of each stage of the data collection operation are described below.

Pretest

Most of the proposed questions on symptoms and related items had been included in earlier surveys based on personal interviews, but there was no previous experience with their use in mail inquiries. To explore the feasibility of this approach for mail surveys and also to check on the adequacy of Census addresses, the type of response that might be expected, and related matters, a three-area, 1,500-person pretest of the Stage I questionnaire was conducted during the summer of 1962. The principal findings were: (*a*) The addresses obtained from the 1960 Census were adequate for locating by mail or tracing individuals in the sample; (*b*) responses to the questions on symptoms obtained through the mail appeared to be consistent with those obtained by personal interviews; (*c*) mail response rates were, if anything, unexpectedly high (about 70%) particularly in view of the age of the sample population; (*d*) the length of the questionnaire, within limits, did not appear to affect materially the response rates. (Two versions were used in the test, one covering more items than the other with regard to socioeconomic and other background data.)

These results led to the use in Stage I of the longer forms tested with minor modifications. The age coverage of the Norwegian sample also was restricted slightly at the upper limit because of the pretest findings. The pretest further permitted efficient design of the follow-up sample of nonrespondents by indicating expected levels of address problems and nonresponse.

Data Collection for Migrant Samples

Stage I questionnaires for the two samples of migrants were mailed in October 1962. Two reminders were sent at 10-day intervals to persons

who did not respond, the second by certified mail. A summary of the Stage I mailing results is presented in table 2.

TABLE 2.—British and Norwegian samples: Stage I status (unweighted)*

	Total migrants		British		Norwegians	
	Number	Percent	Number	Percent	Number	Percent
Total mailed	49, 644	100. 0	31, 793	100. 0	17, 851	100. 0
Total reports	*42, 470*	*85. 5*	*27, 392*	*86. 2*	*15, 078*	*84. 5*
Completed questionnaires†	38, 773	78. 1	24, 821	78. 1	13, 952	78. 2
Decedents	1, 840	3. 7	1, 196	3. 8	644	3. 6
Out-of-scope‡	1, 857	3. 7	1, 375	4. 3	482	2. 7
Nonresponse	*7, 174*	*14. 5*	*4, 401*	*13. 8*	*2, 773*	*15. 5*
Refused	349	0. 7	223	0. 7	126	0. 7
Post office returns, address unknown	4, 699	9. 5	2, 899	9. 1	1, 800	10. 1
Nonreturns	2, 126	4. 3	1, 279	4. 0	847	4. 7
Completed questionnaires†	38, 773	100. 0	24, 821	100. 0	13, 952	100. 0
With positive responses to questions on symptoms	16, 156	41. 7	10, 666	43. 0	5, 490	39. 3
With negative responses to questions on symptoms	22, 617	58. 3	14, 155	57. 0	8, 462	60. 7

*This summary and the others that follow in this article are operational office controls compiled for use as current progress reports during the survey. Later review and reclassifications would make these figures somewhat different from those appearing in the data tables presented in other articles in this issue.

† Preliminary count. Review prior to Stage II mailing resulted in reclassifying about 500 as out-of-scope.

‡ Census records incorrect on place of birth or age, or the person moved from the State in April 1960.

Since no information was available for 14.5 percent of the sample ("nonresponse" in table 2), a subsample of this group excluding refusals was investigated further by field interviewers. The subsample was drawn by the same general procedures as for the British sample in Stage I and involved stratification and selection of counties followed by systematic subsampling of nonrespondents within the large designated counties. There was no subsampling of nonrespondents in the smaller counties.

Table 3 shows the number selected for the subsample and the final classification after extensive efforts by interviewers to locate and interview nonrespondents.

These results indicated that mobility was the chief problem during the 2½ years since the Population Census. Forty-two percent of this group of nonrespondents, or about 6 percent of the over-all sample, were either not located or reported as having moved from the area. Of those located and interviewed, the proportion with positive responses to questions on symptoms (about 41%) was generally similar to that for Stage I respondents. As might be expected, the proportion of those located who refused to participate or were deceased was higher than in Stage I.

These results demonstrate that only about half of the 14.5 percent nonrespondents can be accounted for by unwillingness to cooperate. It is of interest to estimate the amount of nonresponse in the original mail inquiry accounted for by noncooperation and the amount attributable to special features of this inquiry, *e.g.*, the more than 2-year interval elapsing

TABLE 3.—British and Norwegian samples: Stage I nonresponse field follow-up (unweighted)

Follow-up status	Total		British		Norwegians	
	Number	Percent	Number	Percent	Number	Percent
Total in sample	1, 513	100. 0	980	100. 0	533	100. 0
Interviewed	600	39. 7	390	39. 7	210	39. 4
Decedents	71	4. 7	48	4. 8	23	4. 3
Incapacitated	18	1. 2	12	1. 2	6	1. 1
Out-of-scope*	14	0. 9	11	1. 4	3	0. 6
Refused	135	8. 9	87	8. 9	48	9. 0
Located, but not interviewed (not at home, etc.)	35	2. 3	22	2. 2	13	2. 4
Not located	385	25. 4	245	25. 0	140	26. 3
Moved out of sample county	245	16. 2	162	16. 5	83	15. 6
Unaccounted for	10	0. 7	3	0. 3	7	1. 3
Interviewed	600	100. 0	390	100. 0	210	100. 0
With positive responses to questions on symptoms	243	40. 5	150	38. 5	93	44. 3
With negative responses to questions on symptoms	357	59. 5	240	61. 5	117	55. 7

*Census records incorrect on place of birth or age.

between the census date and date of mailing. In the tabulation below we have separated the nonrespondents who would have been ineligible for inclusion, had an up-to-date mailing list been available from the true nonrespondents, using subsample results for the estimation. Somewhat less than 10 percent of the eligibles failed to cooperate in the original mailing and this furnishes a true measure of the nonresponse rate to be expected with a questionnaire mailed to an up-to-date list under similar conditions.

Total mailings	45, 947		
Response:			
Completed questionnaires		38, 773	
Decedents		1, 840	
Out-of-scope		1, 857	
Refusals		349	
Nonresponse:			
Eligible		3, 788	
Ineligible			
Decedents			337
Out-of-scope			65
Not located			1, 822
Moved out of sample county			1, 162
Eligible persons:			
Total	42, 910		
Percent completing questionnaire	90. 4		

The second stage of data collection was a more detailed inquiry on symptoms and related health matters sent in April 1963 to all persons who had reported in Stage I one or more symptoms suggestive of the study diseases and a systematic subsample (for quality check purposes) of 3,000 persons who in Stage I had reported no symptoms. After 3

mailings, completed questionnaires had been returned by 85 percent of those in this sample and another 1 percent was reported as deceased. The disposition of the Stage II sample is shown in table 4.

TABLE 4.—British and Norwegan samples: Stage II status (unweighted)

	Total		British		Norwegians	
	Number	Percent	Number	Percent	Number	Percent
Total mailed	19, 161	100. 0	12, 158	100. 0	7, 003	100. 0
Completed questionnaires	16, 303	85. 1	10, 202	83. 9	6, 101	87. 1
Decedents	213	1. 1	140	1. 2	73	1. 0
Refused	418	2. 2	289	2. 4	129	1. 8
Post office returns, address unknown	563	2. 9	303	2. 5	260	3. 7
Miscellaneous returns	124	0. 6	72	0. 6	52	0. 7
Nonreturns	1, 540	8. 0	1, 152	9. 5	388	5. 5
Total with positive responses to Stage I questions on symptoms	16, 156	100. 0	10, 666	100. 0	5, 490	100. 0
Completed questionnaires	13, 659	84. 5	8, 930	83. 7	4, 729	86. 1
Decedents	199	1. 2	133	1. 2	66	1. 2
Refused	348	2. 2	240	2. 3	108	2. 0
Post office returns, address unknown	373	2. 3	217	2. 0	156	2. 8
Miscellaneous returns	109	0. 7	65	0. 6	44	0. 8
Nonreturns	1, 468	9. 1	1, 081	10. 1	387	7. 0
Total with negative responses to Stage I questions on symptoms	3, 005	100. 0	1, 492	100. 0	1, 513	100. 0
Completed questionnaires	2, 578	85. 8	1, 236	82. 8	1, 342	88. 7
Decedents	14	0. 5	7	0. 5	7	0. 5
Refused	67	2. 2	47	3. 2	20	1. 3
Post office returns, address unknown	79	2. 6	34	2. 3	45	3. 0
Miscellaneous returns	10	0. 3	6	0. 4	4	0. 3
Nonreturns	257	8. 6	162	10. 9	95	6. 3

The U.S.-Born Sample

The Stage I mailing for the U.S.-born sample began in May 1963. The same mailing procedures and timing were used as for the migrants. The returns are given in table 5.

TABLE 5.—U.S.-born sample: Stage I status (unweighted)

	Number	Percent
Total mailed	22, 937	100. 0
Total reports	18, 319	79. 9
Completed questionnaires	15, 293	66. 7
Decedents	351	1. 5
Out-of-scope (foreign-born)	2, 675	11. 7
Nonresponse	4, 618	20. 1
Refused	375	1. 6
Post office returns, address unknown	1, 199	5. 3
Nonreturns	3, 044	13. 3
Completed questionnaires	15, 293	100. 0
With positive responses to questions on symptoms	7, 794	51. 0
With negative responses to questions on symptoms	7, 499	49. 0

For information on the 20 percent who were nonrespondents, a personal interview of a subsample was conducted. The selection of the subsample was done in a manner like that described for the two migrant samples and yielded 2,109 persons in 89 primary sampling units. The final classification of the nonrespondents sampled appears in table 6.

TABLE 6.—U.S.-born sample: Stage I nonresponse field follow-up (unweighted)

Follow-up status	Number	Percent
Total in sample	2, 109	100. 0
Interviewed	1, 212	57. 5
Decedents	42	2. 0
Incapacitated	12	0. 6
Out-of-scope (foreign-born)	255	12. 1
Refused	196	9. 3
Located, but not interviewed (not at home, etc.)	69	3. 3
Not located	121	5. 7
Moved from sample area	169	8. 0
Claimed questionnaire returned	33	1. 6
Interviewed	1, 212	100. 0
With positive responses to questions on symptoms	639	52. 7
With negative responses to questions on symptoms	573	47. 3

The greater success in locating and interviewing nonrespondents from the U.S. sample as compared with the migrants is attributable to the nature of reasons for nonresponse in each sample. Migrant nonrespondents were primarily persons whom the postal service could not locate, and in turn, Census interviewers had difficulty finding. U.S.-born nonrespondents, on the other hand, were easily located but simply failed to complete and return the questionnaire. When visited by interviewers, many could be persuaded to provide the needed information. As was the case for the migrant samples, the proportion of persons reporting symptoms in the field follow-up phase was similar to the corresponding proportion among Stage I respondents. The Stage II mailing, begun in August 1963 for the U.S. sample, covered 9,040 persons, of whom 7,794 had reported symptoms in Stage I and the other 1,246 were a subsample of those without reported symptoms. As shown in table 7, the response rate for Stage II was similar to that for migrants, with 86 percent returning completed questionnaires.

Questionnaire

Stage I.—The questionnaire, Form BN–7, used for the Norwegian sample appears as Appendix A. The same form was used for the British except that references to "Great Britain" replaced those to "Norway." The U.S.-born sample questionnaire was also identical except for deletion of all questions relating to Norway.

Stage II.—The Norwegian Stage II questionnaire, Form BN–11, is reproduced as Appendix B. Again the same form with appropriate references and deletions was used for the British and U.S.-born samples.

Quality review.—All Stage I questionnaires that were returned were

TABLE 7.—U.S.-born sample: Stage II status (unweighted)

			Response to Stage I questions on symptoms			
			One or more positive		All negative	
	Total No.	Percent	Number	Percent	Number	Percent
Total mailed	9,040	100.0	7,794	100.0	1,246	100.0
Completed questionnaires	7,768	85.9	6,664	85.5	1,104	88.6
Decedents	24	0.3	24	0.3	—	—
Refused	273	3.0	235	3.0	38	3.0
Post office returns, address unknown	238	2.6	219	2.8	19	1.5
Miscellaneous returns	19	0.2	16	0.2	3	0.2
Nonreturns	718	7.9	636	8.2	82	6.6

reviewed and the health items 23 through 26 were checked for completeness. If none of these items were marked "Yes" and 1 or more were blank, another form was sent to the individual, with a request for the missing information.

Similarly, the Stage II questionnaires were reviewed and remailed if inadequately completed. The review was more complex than for Stage I. For acceptance, responses were required to items 3d, 6d, 7, 8, 10a, and 15 through 17. If any of these was blank, but the information could be imputed from other entries, however, the form was accepted. The number of edit failures and results from remailing are shown in table 8.

TABLE 8.—Quality review and remail

	Total	British	Norwegian	U.S.-born
Completed Stage I forms received	54,066	24,821	13,952	15,293
Failed edit, number	5,960	2,240	1,729	1,991
percent	11.0	9.0	12.4	13.0
Remailed forms				
Returned, number	5,112	1,954	1,551	1,607
percent	85.8	87.2	89.7	80.7
Completed Stage II forms received	24,071	10,202	6,101	7,768
Failed edit, number	1,365	982		383
percent	5.7	6.0		4.9
Remailed forms				
Returned, number	1,025	759		266
percent	75.1	77.3		69.5

Sibling sample.—The Stage I questionnaires for migrants included questions (*see* item 28b in Appendix A) on the names and addresses of siblings who were still living in the native country. These were sent to the cooperating centers in the two countries for use in mail inquiries similar to those conducted in the United States. Some 8,400 of the British questionnaires and 9,500 of the Norwegian included such names. The information on name and address of living siblings was found to be incomplete, illegible, or otherwise defective in a substantial number of

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cases (about 7,000 for the British, 1,300 for Norwegians). Another mail inquiry was sent to the respondent in these instances to secure more precise information about the siblings. Some improvement was achieved in about 60 percent of the defective reports.

SUMMARY

The work of the U.S. Bureau of the Census is described in study planning and design and collection of data on demographic variables and symptoms of cardiorespiratory disease from samples of British-born, Norwegian-born, and native-born residents of the United States. The study samples were drawn from the 1960 Census of Population (British and Norwegians) and from a national sample (U.S.-born) previously interviewed by the National Health Survey. Mail query was carried out in two stages and returns were received from 90 percent of the eligible population. The study design provided for personal interviews of subsamples of nonrespondents in Stages I and II. Names and addresses of siblings living in Great Britain and Norway were obtained and sent to cooperating centers in those countries for use in similar mail queries.

REFERENCES

(*1*) Reid, D. D.: Studies of disease among migrants and native populations in Great Britain, Norway, and the United States. I. Background and design. Nat Cancer Inst Monogr 19: 287–299, 1966.

(*2*) The Statistical Design of the Health Household-Interview Survey. Health Statistics Report, Series A–2, U.S. Public Health Service, Washington, D.C., July 1958.

APPENDIX A

Survey of Health Characteristics

1a. Is the above address correct?

☐ Yes *(Skip to Question 1b)* ☐ No *(Enter your correct address)*

Number and street or RFD No.	
City or village	
County	State

b. What is your present telephone number? ☐ No telephone

(Please spell out telephone exchange -- for example, LOCUST 7-2468)

Telephone Number

2a. In what county and State in the United States have you lived the longest? *(Specify)*

County	State

b. How many years have you lived in the county (entered in Item 2a), not necessarily in the same house?

1 ☐ Less than 5
2 ☐ 5 - 9
3 ☐ 10 - 19
4 ☐ 20 - 29
5 ☐ 30 - 39
6 ☐ 40 or more

3a. Have you ever lived on a farm since coming to the United States?

1 ☐ Yes 2 ☐ No *(Skip to Question 4)*

b. Altogether, how many years did you live on farms in the United States? .... Number of years ____

4. What is your birth date?

Month	Day	Year

5. Where did your parents live when you were born?

☐ Lived on a farm

City or village
County (Fylke)

(If you left Norway before you were five years old, skip to Question 7)

6a. Where did you live longest in Norway before you came to the United States?

☐ Lived on a farm

City or village
County (Fylke)

b. How many years did you live there? ..... Number of years ____

7. When did you come to the United States to live permanently?

Month	Year

8. Check the category below that best describes your present working status.

1 ☐ I have a job or a business or am looking for work

2 ☐ I am a housewife *(Skip to Question 10)*

3 ☐ I am retired due to disability *(Specify disability)*

____

4 ☐ I am retired for other reasons

5 ☐ I am not working for other reasons

9. What kind of work have you done for the longest period of time in the United States?

☐ I have never worked in the United States
(Skip to Question 10)

a. Kind of work *(For example: Secretary, grocery checker, carpenter)*

b. In what business or industry was this?
(For example: Real estate, retail supermarket, construction)

c. How many years have you done this kind of work, not necessarily with the same employer?.......................... Number of years

d. While doing this kind of work did you-- *(Mark one box for each question)*	Nearly every day	Sometimes but not regularly	Very rarely or never
(1) Lift or carry objects weighing 15 lbs. or more?............	1 ☐	2 ☐	3 ☐
(2) Stand more than half of the time?.....................	1 ☐	2 ☐	3 ☐
(3) Walk or move about more than half of the time?...........	1 ☐	2 ☐	3 ☐
(4) Do heavy work such as dig, shovel, cut, saw, push, etc.?	1 ☐	2 ☐	3 ☐

e. How many hours per week did you usually work on this job?

1 ☐ Under 35 hours
3 ☐ 49 - 60 hours
2 ☐ 35 - 48 hours
4 ☐ More than 60 hours

10. What kind of work did you do for the longest period of time when you lived in Norway?

☐ Did not work in Norway *(Skip to Question 11)*

a. Kind of work *(For example: Secretary, grocery checker, carpenter)*

b. In what business or industry is that? *(For example: Real estate, retail supermarket, construction)*

c. How many years did you do this kind of work, not necessarily with the same employer?.......................... Number of years

11. The following questions are about the amount of physical exercise you usually have taken.

a. When you were 20 to 30 years old how often did you-- *(Mark one box for each question)*	Nearly every week	Sometimes but not regularly	Very rarely or never
(1) do housework?.............	1 ☐	2 ☐	3 ☐
(2) work around the house or yard 4 hours or more per week?....	1 ☐	2 ☐	3 ☐
(3) garden in season?..........	1 ☐	2 ☐	3 ☐
(4) take hikes or walks?	1 ☐	2 ☐	3 ☐
(5) play outdoor sports in season? *(Specify what sports)* ________	1 ☐	2 ☐	3 ☐
(6) play indoor sports?.......... *(Specify what sports)* ________	1 ☐	2 ☐	3 ☐
(7) exercise at club or gymnasium?	1 ☐	2 ☐	3 ☐

b. When you were 40 to 50 years old how often did you-- *(Mark one box for each question)*	Nearly every week	Sometimes but not regularly	Very rarely or never
(1) do housework?.............	1 ☐	2 ☐	3 ☐
(2) work around the house or yard 4 hours or more per week?....	1 ☐	2 ☐	3 ☐
(3) garden in season?..........	1 ☐	2 ☐	3 ☐
(4) take hikes or walks?	1 ☐	2 ☐	3 ☐
(5) play outdoor sports in season? *(Specify what sports)* ________	1 ☐	2 ☐	3 ☐
(6) play indoor sports?.......... *(Specify what sports)* ________	1 ☐	2 ☐	3 ☐
(7) exercise at club or gymnasium?	1 ☐	2 ☐	3 ☐

12a. Do you smoke cigarettes now?
1 ☐ Yes, regularly
2 ☐ No
3 ☐ Occasionally (usually less than one cigarette per day)

b. If you now smoke, how many cigarettes do you usually smoke per day? Number of cigarettes

c. Do you inhale?
1 ☐ Yes
2 ☐ No

d. Have you ever regularly smoked more cigarettes than you do now?
1 ☐ Yes
2 ☐ No

e. What is the maximum number of cigarettes you ever smoked per day for as long as one year?.............................. Number of cigarettes

f. How old were you when you began to smoke cigarettes? .... Age

13a. If you do not smoke cigarettes now, did you ever smoke them?

1 ☐ Yes, regularly
2 ☐ No, never
3 ☐ Occasionally (usually less than one cigarette per day)

b. If you used to smoke regularly, what is the maximum number of cigarettes you ever smoked per day for as long as a year?	Number of cigarettes
c. How old were you when you began to smoke cigarettes?	Age

d. Did you inhale?

1 ☐ Yes 2 ☐ No

e. When did you stop smoking cigarettes? *(Give year)*	Year

f. Why did you stop?

14. Did you smoke more cigarettes when you lived in Norway than you do now?

1 ☐ Have never smoked
2 ☐ Did not smoke cigarettes in Norway
3 ☐ Yes, smoked more
4 ☐ No, smoked less
5 ☐ Smoked about the same

15a. Have you ever smoked cigars?

1 ☐ No
2 ☐ Used to smoke them but do not now
3 ☐ Now smoke occasionally (less than one per day)
4 ☐ Now smoke regularly

b. Do you inhale?

1 ☐ Yes 2 ☐ No

c. Did you smoke more cigars when you lived in Norway than you do now?

1 ☐ Have never smoked cigars
2 ☐ Did not smoke cigars in Norway
3 ☐ Smoked fewer cigars in Norway
4 ☐ Smoked about the same
5 ☐ Smoked more cigars in Norway

16a. Have you ever smoked a pipe?

1 ☐ No
2 ☐ Used to smoke a pipe but not now
3 ☐ Now smoke a pipe occasionally (less than once a day)
4 ☐ Now smoke one regularly

b. Do you inhale?

1 ☐ Yes 2 ☐ No

c. Did you smoke a pipe more when you lived in Norway than you do now?

1 ☐ Have never smoked a pipe
2 ☐ Did not smoke a pipe in Norway
3 ☐ Smoked less in Norway
4 ☐ Smoked about the same
5 ☐ Smoked more in Norway

17a. How tall are you (without shoes)?..	Feet	Inches
b. How much do you weigh in indoor clothing?	Weight *(Pounds)*	
c. What is the most you have ever weighed for at least one year?	Weight *(Pounds)*	
d. How much did you weigh when you were 20 to 25 years old?	Weight *(Pounds)*	
(If you came to the United States before age 5, skip to Question 18) **e. How much did you weigh when you came to the United States to live?**...........	Weight *(Pounds)*	

18. Please give the following information about your mother.

a. Date of birth

Month	Year

b. Is she now living?

1 ☐ **Yes--How old is she now?**...... Age

2 ☐ No --*(Please give the date of her death)*

Month	Year

19. Please give the following information about your father.

a. Date of birth

Month	Year

b. Is he now living?

1 ☐ **Yes--How old is he now?** ...... Age

2 ☐ No --*(Please give the date of his death)*

Month	Year

20. What is the usual temperature in your living room during the evening in the winter?............................	Temperature *(Fahrenheit)*

21. In the winter do you usually sleep with your bedroom windows--

(Mark one box)

1 ☐ Open?
2 ☐ Closed with heat off?
3 ☐ Closed with the heat on?

(If you left Norway before age 5, skip to Question 23a)

22. When you lived in Norway, in the winter, did you sleep with your bedroom windows--

(Mark one box)

1 ☐ Open?
2 ☐ Closed with the heat off?
3 ☐ Closed with the heat on?

23a. Do you usually cough first thing in the morning in the winter?

1 ☐ Yes 2 ☐ No

b. Do you usually bring up any phlegm from your chest first thing in the morning in the winter?

1 ☐ Yes 2 ☐ No

c. Are you ever troubled by shortness of breath when hurrying on the level or walking up a slight hill?

1 ☐ Yes
2 ☐ No.
3 ☐ Never hurry or walk uphill

24a. Does your chest ever sound wheezy or whistling?

1 ☐ Yes 2 ☐ No

b. During the past 3 years have you had any chest illness which has kept you off work, indoors, at home, or in bed?

1 ☐ Yes 2 ☐ No

25a. Have you ever had any pain or discomfort in your chest?

1 ☐ Yes *(Answer Questions 25b and 25c)* 2 ☐ No *(Skip to Question 26)*

b. Do you get this pain when you walk uphill or hurry?

1 ☐ Yes
2 ☐ No
3 ☐ Never hurry or walk uphill

c. Do you get it when you walk at an ordinary pace on the level?

1 ☐ Yes 2 ☐ No

26. Have you ever had a severe pain across the front of your chest lasting for half an hour or more?

1 ☐ Yes 2 ☐ No

27a. During the past 12 months did you see a doctor because of ill health?

1 ☐ Yes 2 ☐ No *(Go to Question 27b)*

What did he say was wrong with you?

b. If "No," when did you last consult a doctor because of ill health?

Month	Year

What did he say was wrong with you?

28a. How many brothers and sisters did you have?......	Number of brothers	Number of sisters

b. Do you have any brothers or sisters now living in Norway?

1 ☐ Yes *(Please give the following information)* 2 ☐ No *(Skip to Question 28c)*

Name (Last)	(First)
Address (City or village)	
(County (Fylke)	
Name (Last)	(First)
Address (City or village)	
County (Fylke)	
Name (Last)	(First)
Address (City or village)	
County (Fylke)	

c. Do you have any brothers or sisters who died in Norway?

1 ☐ Yes *(Please give the following information for those 5 years old or older when they died)* 2 ☐ No

Name (Last)	(First)		
Place of death (City or village)			
County (Fylke)			
Age at death		Date of death	
Name (Last)	(First)		
Place of death (City or village)			
County (Fylke)			
Age at death		Date of death	
Name (Last)	(First)		
Place of death (City or village)			
County (Fylke)			
Age at death		Date of death	

APPENDIX B

Detailed Health Inquiry--Survey of Health Characteristics

1. Do you usually cough first thing in the morning --

a. In the winter?

1 ☐ Yes. 2 ☐ No

b. In the summer?

1 ☐ Yes 2 ☐ No

2. Do you usually cough during the day, or at night --

a. In the winter?

1 ☐ Yes 2 ☐ No

b. In the summer?

1 ☐ Yes 2 ☐ No

3. If "Yes" to any part of Question 1 or 2:

a. How old were you when you began to cough like this? Age

b. Did you cough like this when you were living in Norway?

1 ☐ Yes 2 ☐ No

c. If "Yes," has your cough gotten better or worse since coming to the United States?

1 ☐ Now better

2 ☐ Now worse

3 ☐ Now about the same

d. Do you cough like this on most days for as much as three months each year?

1 ☐ Yes 2 ☐ No

e. Did you cough like this when you lived in Norway?

1 ☐ Yes 2 ☐ No

4. Do you usually bring up any phlegm from your chest first thing in the morning --

a. In the winter?

1 ☐ Yes 2 ☐ No

b. In the summer?

1 ☐ Yes 2 ☐ No

5. Do you bring up any phlegm from your chest during the day, or at night --

a. In the winter?

1 ☐ Yes 2 ☐ No

b. In the summer?

1 ☐ Yes 2 ☐ No

6. If "Yes" to any part of Question 4 or 5:

a. How old were you when you began to do this? Age

b. Did you bring up phlegm like this when you were living in Norway?

1 ☐ Yes 2 ☐ No

c. If "Yes," has this condition gotten better or worse since coming to the United States?

1 ☐ Now better

2 ☐ Now worse

3 ☐ Now about the same

d. Do you bring up phlegm like this on most days for as much as three months each year?

1 ☐ Yes 2 ☐ No

e. Did you when you lived in Norway?

1 ☐ Yes 2 ☐ No

7. Have you had a period of increased cough and phlegm lasting 3 weeks or more during the past three years?

1 ☐ Yes, only one period

2 ☐ Yes, two or more periods

3 ☐ No

8. If you DO NOT usually cough or bring up phlegm from your chest, have you had a period of cough and phlegm lasting 3 weeks or more during the past three years?

1 ☐ Yes, only one period

2 ☐ Yes, two or more periods

3 ☐ No

9. Are you ever troubled by shortness of breath --

a. When hurrying or on the level?

1 ☐ Yes 2 ☐ No

b. Walking up a slight hill?

1 ☐ Yes 2 ☐ No

10. a. Do you get short of breath walking with other people at an ordinary pace on the level?

1 ☐ Yes 2 ☐ No

b. Do you have to stop for breath when walking at your own pace on the level?

1 ☐ Yes 2 ☐ No

11. Are you short of breath when you wash or dress yourself?

1 ☐ Yes 2 ☐ No

12. a. Does your chest ever sound wheezy or whistling?

1 ☐ Yes 2 ☐ No

b. If "Yes" in Question 12a; do you get this with colds?

1 ☐ Yes 2 ☐ No

c. Do you get this occasionally when you do not have a cold?

1 ☐ Yes 2 ☐ No

d. Do you get this most days and nights?

1 ☐ Yes 2 ☐ No

13. a. Have you ever had attacks of shortness of breath with wheezing?

1 ☐ Yes 2 ☐ No

b. If "Yes," how old were you when you began to have these attacks?	Age

c. Do you still get these attacks?

1 ☐ Yes 2 ☐ No

14. Do you usually have a stuffy nose or catarrh at the back of your nose --

a. In the winter?

1 ☐ Yes 2 ☐ No

b. In the summer?

1 ☐ Yes 2 ☐ No

c. If "Yes" in 14a or 14b, do you have this on most days for as much as 3 months each year?

1 ☐ Yes 2 ☐ No

d. Did this begin when you were living in Norway?

1 ☐ Yes 2 ☐ No

e. If "Yes," has it changed since coming to the United States?

1 ☐ Now not so bad

2 ☐ Now worse

3 ☐ Now about the same

15. a. Have you ever had any pain or discomfort in your chest?

1 ☐ Yes 2 ☐ No

If "Yes," do you get it --

b. When you walk uphill or hurry?

1 ☐ Yes 2 ☐ No

c. When you walk at an ordinary pace on the level?

1 ☐ Yes 2 ☐ No

16. When you get any pain or discomfort in your chest, what do you do?

1 ☐ Stop

2 ☐ Slow down

3 ☐ Continue at same pace

17. a. Does it go away if you stand still?

1 ☐ Yes 2 ☐ No

b. How soon?

1 ☐ 10 minutes or less

2 ☐ More than 10 minutes

18. How often have you had this pain or discomfort?

1 ☐ Only once

2 ☐ Several times

3 ☐ Many times

19. How old were you when you first had this pain or discomfort?	Age

20. When did you last have this?

Month	Year

21. Does it sometimes come when you are excited or emotionally upset?

1 ☐ Yes 2 ☐ No

22. a. Have you ever seen a doctor for this pain or discomfort?

1 ☐ Yes 2 ☐ No

b. If "Yes," what did he say it was?

23. a. Have you ever had a severe pain across the front of your chest lasting for half an hour or more?

1 ☐ Yes 2 ☐ No

If "Yes," please give the following information about each attack.

	b. Date of attack		c. Did you see a doctor?	d. What did he say it was?
	Month	Year		
1			1 ☐ Yes → 2 ☐ No	
2			1 ☐ Yes → 2 ☐ No	
3			1 ☐ Yes → 2 ☐ No	

24. a. During the past 3 YEARS have you had any chest illness which has kept you from work, indoors, at home, or in bed?

1 ☐ Yes 2 ☐ No

If "Yes," please give the following information for each occurence.

	b. Date of occurence		c. How long were you ill?	d. Did you see a doctor?	e. What did he say was wrong with you?
	Month	Year			
1		196___		1 ☐ Yes → 2 ☐ No	
2		196___		1 ☐ Yes → 2 ☐ No	
3		196___		1 ☐ Yes → 2 ☐ No	
4		196___		1 ☐ Yes → 2 ☐ No	
5		196___		1 ☐ Yes → 2 ☐ No	

25. Hove you ever been told by o doctor thot you hove or hove hod ony of the following?

	o. Condition (Mark "Yes" or "No" for each condition. For each "Yes," complete Questions b, c, and d.)		b. Age when this first occurred or began to trouble you	c. Does it still trouble you?	d. Dote of lost occurence	
					Month	Year
1	Bronchitis?	1 ☐ Yes→ 2 ☐ No		1 ☐ Yes 2 ☐ No		
2	Bronchiectasis?	1 ☐ Yes→ 2 ☐ No		1 ☐ Yes 2 ☐ No		
3	Asthma?	1 ☐ Yes→ 2 ☐ No		1 ☐ Yes 2 ☐ No		
4	Emphysemo?	1 ☐ Yes→ 2 ☐ No		1 ☐ Yes 2 ☐ No		
5	Pneumonia?	1 ☐ Yes→ 2 ☐ No		1 ☐ Yes 2 ☐ No		
6	Pleurisy?	1 ☐ Yes→ 2 ☐ No		1 ☐ Yes 2 ☐ No		
7	Allergy?	1 ☐ Yes→ 2 ☐ No		1 ☐ Yes 2 ☐ No		
8	Sinus trouble?	1 ☐ Yes→ 2 ☐ No		1 ☐ Yes 2 ☐ No		
9	Hoy Fever?	1 ☐ Yes→ 2 ☐ No		1 ☐ Yes 2 ☐ No		
10	Diobetes?	1 ☐ Yes→ 2 ☐ No		1 ☐ Yes 2 ☐ No		
11	Heort Attock (coronory)?	1 ☐ Yes→ 2 ☐ No		1 ☐ Yes 2 ☐ No		
12	Angino Pectoris?	1 ☐ Yes→ 2 ☐ No		1 ☐ Yes 2 ☐ No		
13	Stroke?	1 ☐ Yes→ 2 ☐ No		1 ☐ Yes 2 ☐ No		
14	Heort trouble?	1 ☐ Yes→ 2 ☐ No		1 ☐ Yes 2 ☐ No		
15	High blood pressure?	1 ☐ Yes→ 2 ☐ No		1 ☐ Yes 2 ☐ No		

COMMENTS

Studies of Disease Among Migrants and Native Populations in Great Britain, Norway, and the United States. III. Prevalence of Cardiorespiratory Symptoms Among Migrants and Native-Born in the United States [1, 2]

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THE initial phase of this comparative study called for the collection of information by postal questionnaire on the demographic characteristics, personal habits, residential history, and the presence of certain cardiorespiratory symptoms in a sample of residents born in the United States, Norway, or Britain. The results of that postal inquiry provide data immediately available for analysis. This paper gives a preliminary account of the distribution of cardiorespiratory symptoms in relation to some of the personal characteristics of those thus surveyed.

MATERIALS AND METHODS

The collection and processing of primary data by the U.S. Bureau of the Census have been described by Pearl *et al.* (*1*). The material transmitted by that Bureau to the National Heart Institute for each migrant respondent consisted of:

(*a*) three punch cards summarizing responses to the stage I questionnaire
(*b*) three punch cards summarizing stage II responses
(*c*) one punch card summarizing answers to the 1960 Census population questionnaire
(*d*) one control punch card giving certain personal identification data used in the Census phase of the inquiry

The material transmitted for each native-born respondent was similar but with some exceptions: Stage I replies occupied two punch cards;

[1] Supported in part by the Public Health Service research grant HE-04775 from the National Institutes of Health.
[2] Some of the mortality data for residents of the United States cited in this paper were made available from another study supported by the Public Health Service research grant CH-00075 from the Division of Community Services.
[3] National Institutes of Health, Public Health Service, U.S. Department of Health, Education, and Welfare.

certain replies to the National Health Survey questions replaced the 1960 Census information available for migrants; and items (*c*) and (*d*) were combined into one card. The Census and National Health Survey data, which have not been used in the present report, contain supplementary information on income, education, marital status, previous military service, and, for migrants only, housing. All data for each respondent were merged on to Honeywell 800 magnetic tapes. These constitute the basic source of the information contained in this report. Records were available from all four sources of data mentioned above for 98 to 99 percent of individuals in each of the three samples, and the data presented are based on the merged data for these individuals. The stage I and stage II respondents passing this merge procedure are classified in table 1 by nativity, age, and sex, in table 2 by nativity, sex, and urban-rural classification, and in table 3 stage I respondents are shown by nativity and State. All tables from table 7 on are confined to respondents in the age group 35 to 74.

The symptom information on which this report is based is provided by answers to questions on the stage II questionnaire (pp. 317–320); the only function of the symptom questions on stage I was to provide a screen. Results are shown for four symptom complexes.

(*a*) "Persistent cough and phlegm," defined as both cough and the production of phlegm on most days for at least 3 months each year ("yes" to questions 3d and 6d on the stage II questionnaire).

(*b*) "Chronic bronchitis," defined as persistent cough and phlegm ("yes" to both 3d and 6d), with shortness of breath while walking with other

TABLE 1.—Number of stage I and stage II respondents by nativity, age, and sex

Age at questionnaire*	Total	British-born		Norwegian-born		Native-born	
		Male	Female	Male	Female	Male	Female
Stage I:							
30–34	891	10	301	4	93	5	478
35–44	9, 427	1, 415	2, 408	600	669	1, 717	2, 618
45–54	10, 993	2, 348	2, 144	929	882	2, 147	2, 543
55–64	16, 275	4, 570	3, 783	2, 601	2, 094	1, 514	1, 713
65–74	13, 091	3, 142	3, 099	2, 372	2, 361	907	1, 210
75+	2, 502	847	914	282	295	64	100
Unknown	1	—	—	—	—	1	—
Total	53, 180	12, 332	12, 649	6, 788	6, 394	6, 355	8, 662
Stage II:							
30–34	340	0	88	3	13	2	234
35–44	3, 630	561	831	196	207	757	1, 078
45–54	4, 383	973	715	308	263	1, 033	1, 091
55–64	5, 922	1, 901	1, 067	964	609	705	676
65–74	4, 596	1, 282	869	838	720	425	462
75+	877	337	284	107	95	25	29
Total	19, 748	5, 054	3, 854	2, 416	1, 907	2, 947	3, 570

*This exceeds age at time of Census by about 2 years. The group 35 to 44 therefore includes no males aged 35 and 36, while the group 30 to 34 includes no females aged 30 and 31.

Table 2.—Number of stage I and stage II respondents by nativity, residence, and sex

Residence	Total	British-born		Norwegian-born		Native-born	
		Male	Female	Male	Female	Male	Female
Stage I:							
In standard metropolitan statistical area	45, 090	11, 479	11, 483	5, 712	5, 546	4, 508	6, 362
Other urban	3, 653	507	690	431	377	697	951
Rural nonfarm	3, 044	319	439	401	308	705	872
Rural farm	1, 393	27	37	244	163	445	477
Total	53, 180	12, 332	12, 649	6, 788	6, 394	6, 355	8, 662
Stage II:							
In standard metropolitan statistical area	16, 540	4, 718	3, 478	2, 028	1, 622	2, 083	2, 611
Other urban	1, 416	192	225	156	127	333	383
Rural nonfarm	1, 228	131	141	151	94	330	381
Rural farm	564	13	10	81	64	201	195
Total	19, 748	5, 054	3, 854	2, 416	1, 907	2, 947	3, 570

Table 3.—Number of stage I respondents by nativity and State

State	Total	British-born	Norwegian-born	Native-born
New York	11, 643	5, 728	3, 482	2, 433
New Jersey	4, 577	2, 720	844	1, 013
Pennsylvania	4, 956	2, 574	107	2, 275
Ohio	2, 461	1, 003	69	1, 389
Illinois	4, 294	1, 438	1, 317	1, 539
Michigan	4, 281	2, 796	224	1, 261
Wisconsin	1, 590	166	656	768
Minnesota	2, 290	172	1, 719	399
North Dakota	562	0	475	87
Washington	3, 471	711	2, 221	539
California	9, 425	5, 325	1, 673	2, 427
Massachusetts	3, 630	2, 348	395	887
Total	53, 180	24, 981	13, 182	15, 017

people at an ordinary pace ("yes" to question 10a), and at least one period of increased cough and phlegm production lasting 3 weeks or more during the 3 years preceding the inquiry ("yes" to question 7).

(*c*) "Angina," defined as the occurrence of pain or chest discomfort when walking uphill or hurrying ("yes" to question 15b), to which the respondent reacts by stopping or slowing down (responses 1 or 2 to question 16), and which goes away in 10 minutes or less, if one stands still (response 1 to question 17b).

(*d*) "Possible infarction," an episode of severe pain across the front of the chest lasting for half an hour or more ("yes" to question 23a).

There were two types of nonresponse to be considered in the summary of data for analysis: (*a*) nonresponse to the stage I questionnaire; (*b*) Nonresponse to the stage II questionnaire by respondents to stage I questionnaire reporting one or more positive symptoms. To investigate the effect of nonresponse to stage I, the original study plan called for field interviews of a subsample of the nonrespondents. Table 4 compares for each of the three samples the proportion responding positively to one or more symptom questions among respondents and field-interviewed nonrespondents. The difference appears small and within sampling error. One cannot entirely exclude the possibility that a more detailed analysis would disclose less trivial differences, but the possibility seems somewhat remote and no effort has been made to adjust mail replies for the results of the field follow-up.

TABLE 4.—Comparison of percent with positive responses to one or more symptom questions; respondents to stage I mailed questionnaire and nonrespondents interviewed in field follow-up by nativity

Nativity	Mail respondents	Field follow-up
British-born	43	39
Norwegian-born	39	44
Native-born	51	53

Approximately 15 percent of the stage I positive respondents to whom stage II questionnaires were sent failed to respond (table 5). In view of the results with the full field follow-up of nonrespondents to the stage I questionnaire, further follow-up of stage II nonrespondents seemed unprofitable. The prevalence rates given in table 7 and following tables are obtained by multiplication of the prevalence among stage II respondents by the percentage of symptom-positives to the stage I inquiry. This is in principle equal to the estimate that would have been obtained if (*a*) the two stages had been consolidated into one, (*b*) stage II nonrespondents had the same symptom prevalence rates as respondents, and (*c*) the conduct of the inquiry in two stages had no effect on stage II response.

TABLE 5.—Stage II response rates by nativity, age, and sex

Age at questionnaire	British-born		Norwegian-born		Native-born	
	Male	Female	Male	Female	Male	Female
< 35	—	81	—	84	—	89
35–44	86	88	87	87	85	84
45–54	87	90	88	87	85	85
55–64	87	89	86	84	84	85
65–74	87	88	86	83	84	85
75+	86	84	82	80	78	74

Since stage I was used as a screen, the failure of persons who truly had symptoms to answer positively at this stage would lead to an underestimation of the symptom prevalence. To estimate the importance of such failures, stage II questionnaires were sent to subsamples of 1,000 to 1,500 negative respondents to stage I in each of the three nativity groups. Stage II responses are thus available for approximately 4,000 negative stage I respondents and table 6 compares the stage II symptom prevalence for the two groups. Theoretically, a weighted combination of responses would then provide an estimate of the prevalence of the four symptom complexes among the defined populations. In fact, the reported prevalence among the stage I negatives is so low that little error is introduced by its treatment as zero, and the computations are considerably simplified. Thus the more accurate estimate based on the prevalence of persistent cough and phlegm given in table 6 would be given by

$$\frac{12.7 \times 22{,}440 + 0.7 \times 30{,}740}{53{,}180} = 5.8\%$$

where 22,440 is the number of stage I respondents reporting one or more symptoms. The simpler treatment gives an estimate of 5.4 percent. The over-all prevalences are thus slightly underestimated, but effect on comparisons among the different classes is, in this case, smaller than 0.4 percent. Generally, the error is trivial and has been neglected throughout the analysis.

TABLE 6.—Comparison of prevalence of four symptom complexes among positives and a sample of negatives to stage I questions, three nativity groups combined

	Positive to one or more stage I symptom questions (percent)	Negative to all stage I symptom questions (percent)
Persistent cough and phlegm	12. 7	0. 7
Chronic bronchitis	2. 2	0. 0
Angina	15. 0	1. 6
Possible infarction	11. 9	1. 1

Because the sampling fraction was not constant (*1*), it is theoretically necessary to combine the various segments of the British and Norwegian samples by weighting. The present report is based, however, on unweighted totals. In subsequent reports in which mortality for the 12 States is compared against death rates in the sample, the latter will be appropriately weighted.

The age and smoking-class standardized rates or ratios reported here were calculated by the indirect method, and pooled rates for the three sample groups were used as standard rates. The use of the indirect method in comparisons among many groups can lead to anomalous results. One alternative is to eliminate the effects of age and smoking-

class by use of least square methods. A calculation along these lines for certain of the groups compared in this study led, however, to very similar results to those obtained by the indirect method. It seems unlikely, therefore, that the conventional method of standardization used in this report has produced any anomalous relationships.

RESULTS

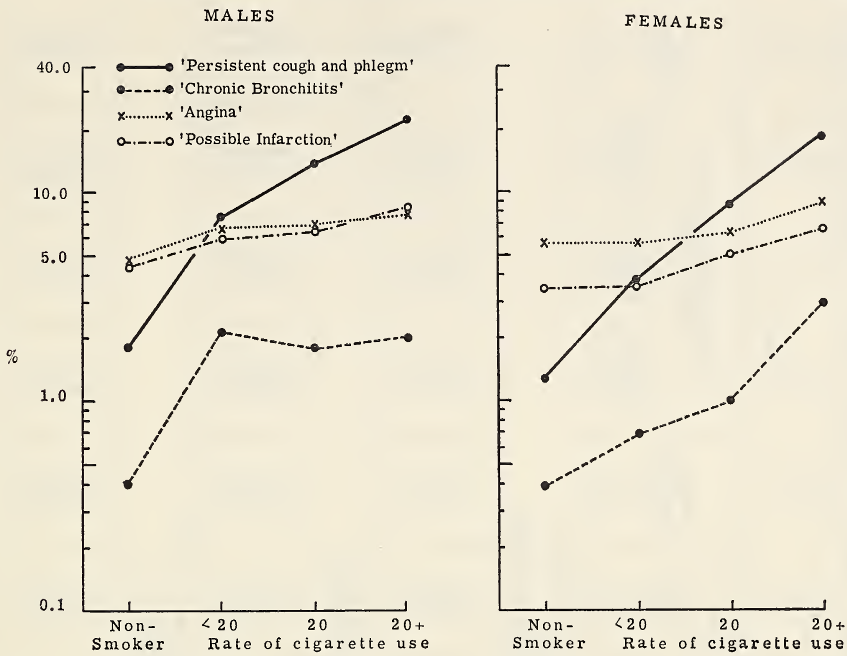
Table 7 presents the consolidated data on prevalence for four symptom categories—persistent cough and phlegm, chronic bronchitis, angina, and possible infarction—by age, sex, and smoking habits totaled over the three nativity groups studied in the United States. The rates in this table were used as the standard for computation of adjusted rates and ratios reported in subsequent tables and charts, except for table 10 in which the standard is given by the rate for both sexes combined.

The most striking feature is the gradient by smoking class displayed for each set of symptoms. Within each symptom category the data for males and females substantially agreed in this respect (text-fig. 1). The relative rise in prevalence with increased cigarette smoking was more pronounced for the respiratory symptoms, particularly the milder form of persistent cough and phlegm, than for the cardiovascular symptoms. Within each of the four age groups considered, the gradients by smoking class persisted. Inspection of the rates for males suggests rather constant absolute differences in prevalence between nonsmokers and heavy cigarette smokers. For angina and possible infarction this is generally accompanied by a rise in rates with age among all classes of smokers, so that the relative smoking gradient decreases with increase in age. For females the same pattern of a rise in rates with age holds for cardiovascular symptoms but not so clearly for respiratory disturbance. In some instances, as in possible infarction among heavy-smoking females, the rates are based on small numbers.

For respiratory symptoms, particularly persistent cough and phlegm, the prevalence among ex-smokers was far lower than among any class of current cigarette smokers and approached the figures for nonsmokers. For angina and possible infarction, on the other hand, the experience for ex-smokers remained close to the level prevailing for current smokers and substantially above that reported for nonsmokers.

When adjustments for smoking habits are made, a rise in prevalence among males of persistent cough and phlegm with age becomes apparent (text-fig. 2), a feature also evident for chronic bronchitis. The cardiovascular symptoms present a linear rise in prevalence with age for males; the slopes are approximately the same for angina and possible infarction. Among females, the age gradient for all symptom categories is less pronounced.

Table 7 shows that the prevalence of persistent cough and phlegm, like that for chronic bronchitis, was much higher among men. This sex differential is diminished by adjustment for differences in smoking history



TEXT-FIGURE 1.—Prevalence of symptoms for persistent cough and phlegm, chronic bronchitis, angina, and possible infarction by sex and daily rate of cigarette use. Combined study populations (British-, Norwegian-, and native-born) aged 35 to 74 years. United States, 1962–63.

(text-fig. 2). The male-female contrasts for cardiovascular symptoms presented quite a different picture. The crude prevalence of angina was higher among women at younger ages, and adjustment for smoking habits made the sex differential more striking. The data suggest that, because of a steeper progression in rates with age among males, the sex differential for this symptom complex may be reversed at older ages. In possible infarction, a higher male-female ratio of prevalence at older ages appeared in both the crude and smoking-adjusted rates.

Symptom prevalence ratios among the three groups of British-born, Norwegian-born, and native-born are compared in table 8. Age-adjusted rates are given in table 9. The characteristic smoking-class gradients for each symptom category noted in the review of the consolidated data persisted within each nativity group. The prevalence of the respiratory syndromes, persistent cough and phlegm and chronic bronchitis, is usually higher among U.S.-born males than among their migrant counterparts. Norwegian male migrants tend to have a lower prevalence than British.

Cardiovascular symptoms presented a similar pattern. Norwegian-born males had the lowest and native-born males usually the highest prevalence of angina and possible infarction within each smoking class. While native-born females also exhibited the highest prevalence, the differentials were less impressive.

781-871—65——22

TABLE 7.—Number of persons, with symptoms of persistent cough and phlegm, chronic bronchitis, angina, and possible infarction, with rate per 100 population, by sex, age, and smoking habits. Combined study population (British-, Norwegian-, and native-born), age 35–74. United States, 1962–63

Age at questionnaire	Males						Females					
	Total	Never smoked	Current cigarette smoker (daily rates)			Ex-smoker	Total	Never smoked	Current cigarette smoker (daily rates)			Ex-smoker
			<1 pack	1 pack	1+ pack				<1 pack	1 pack	1+ pack	
(a) Prevalence (percent)												
Persistent cough and phlegm												
35–44	8. 6	2. 6	4. 2	9. 6	21. 2	1. 9	4. 7	1. 5	3. 8	8. 7	19. 4	1. 3
45–54	9. 6	0. 7	6. 3	12. 6	22. 4	2. 2	4. 3	1. 3	4. 0	8. 9	16. 8	2. 8
55–64	8. 8	1. 4	8. 3	13. 7	22. 0	4. 3	2. 7	0. 9	3. 6	8. 4	20. 1	2. 3
65–74	7. 6	2. 2	8. 9	18. 0	24. 3	5. 4	2. 2	1. 5	3. 4	10. 8	17. 2	3. 3
Chronic bronchitis												
35–44	0. 6	0. 3	0. 0	0. 5	1. 8	0. 1	0. 7	0. 3	0. 6	0. 4	3. 3	0. 6
45–54	0. 8	0. 0	1. 5	1. 1	1. 3	0. 5	0. 6	0. 2	0. 6	1. 0	1. 8	0. 4
55–64	1. 6	0. 3	2. 6	2. 0	2. 2	1. 3	0. 6	0. 3	0. 3	1. 4	5. 0	1. 0
65–74	2. 0	0. 7	2. 9	3. 9	5. 6	1. 5	0. 7	0. 5	1. 5	3. 3	0. 0	1. 0
Angina												
35–44	4. 3	2. 3	2. 9	4. 3	6. 5	4. 6	5. 7	5. 2	5. 9	5. 6	9. 3	4. 9
45–54	5. 8	3. 3	6. 2	5. 0	8. 3	5. 6	6. 5	5. 9	6. 0	7. 7	7. 7	7. 4
55–64	7. 4	4. 7	7. 0	7. 2	8. 1	8. 9	6. 3	5. 9	5. 9	5. 7	10. 7	8. 8
65–74	8. 8	5. 9	8. 1	11. 6	10. 4	10. 5	6. 3	6. 0	4. 4	8. 3	10. 3	11. 5

						Possible infarction						
35-44	4.3	2.3	4.4	5.1	6.0	3.5	3.9	2.6	3.5	4.1	7.9	4.7
45-54	5.7	2.0	5.6	5.6	8.2	5.6	3.7	2.6	3.0	4.7	6.7	5.4
55-64	7.3	4.6	6.1	6.5	9.5	8.9	4.0	3.4	4.1	5.5	5.0	5.8
65-74	7.9	6.1	6.8	10.3	10.0	8.9	4.7	4.4	4.2	9.2	0.0	6.9
						(b) Number observed						
						Persistent cough and phlegm						
35-44	259	15	17	58	156	13	206	23	43	61	71	8
45-54	416	5	37	119	231	24	178	23	38	53	48	16
55-64	610	17	96	189	214	94	142	31	32	35	32	12
65-74	368	33	70	115	61	89	96	54	14	13	5	10
						Chronic bronchitis						
35-44	19	2	—	3	13	1	31	5	7	3	12	4
45-54	37	—	9	10	13	5	23	4	6	6	5	2
55-64	111	4	30	28	21	28	31	9	3	6	8	5
65-74	97	10	23	25	14	25	32	19	6	4	0	3
						Angina						
35-44	131	13	12	26	48	32	250	80	66	39	34	31
45-54	253	23	36	47	85	62	272	105	57	46	22	41
55-64	513	57	81	99	79	197	339	200	52	24	17	46
65-74	425	89	64	74	26	172	280	214	18	10	3	35
						Possible infarction						
35-44	130	13	18	31	44	24	168	40	40	29	29	30
45-54	246	14	33	53	84	62	153	46	29	28	19	31
55-64	504	55	70	90	92	197	213	116	36	23	8	30
65-74	383	91	54	66	25	147	208	159	17	11	0	21

TABLE 8.—Number of persons with symptoms of persistent cough and phlegm, chronic bronchitis, angina, and possible infarction, with rate per 100 population, by sex, age, and smoking habits for British-, Norwegian-, and native-born. United States, 1962–63

a. MALES

Prevalence (percent)

Age at questionnaire	British-born						Norwegian-born						Native-born					
	Total	Never smoked	Current cigarette smoker (daily rates)			Ex-smoker	Total	Never smoked	Current cigarette smoker (daily rates)			Ex-smoker	Total	Never smoked	Current cigarette smoker (daily rates)			Ex-smoker
			<1 pack	1 pack	1+ pack				<1 pack	1 pack	1+ pack				<1 pack	1 pack	1+ pack	
	Persistent cough and phlegm																	
35–44	7.2	1.3	3.7	8.6	17.5	2.0	5.8	2.4	0.0	10.5	14.2	0.8	10.9	3.9	7.2	10.2	26.8	2.2
45–54	8.0	0.3	4.3	11.1	18.7	1.7	6.1	0.0	2.9	11.9	14.5	1.3	13.0	1.5	11.0	14.6	29.1	3.2
55–64	9.0	1.2	7.0	15.6	20.1	3.7	7.0	1.3	8.8	9.1	22.7	3.3	11.7	2.2	12.3	14.1	27.2	8.2
65–74	7.8	1.7	7.9	17.7	25.5	4.5	5.3	1.4	8.3	17.9	20.0	4.0	13.5	6.9	15.2	19.3	26.4	13.1
	Chronic bronchitis																	
35–44	0.3	0.0	0.0	0.0	1.0	0.4	0.2	0.0	0.0	0.0	0.9	0.0	1.1	0.8	0.0	1.1	2.7	0.0
45–54	0.4	0.0	1.4	0.7	0.2	0.0	0.1	0.0	0.0	0.6	0.0	0.0	1.7	0.0	2.5	1.7	2.8	1.2
55–64	1.5	0.3	2.4	1.7	2.1	1.2	1.3	0.3	2.6	1.7	2.2	0.7	2.5	0.4	3.2	3.8	2.2	2.8
65–74	2.1	0.2	2.3	4.8	6.6	1.4	1.1	0.5	2.8	2.3	1.7	1.0	4.0	2.6	6.5	3.4	7.5	3.4
	Angina																	
35–44	3.0	2.2	1.1	2.0	4.8	4.1	2.2	0.0	0.0	4.2	3.5	2.4	6.4	3.1	7.2	6.4	9.0	5.9
45–54	5.2	3.2	4.3	4.5	6.5	6.6	3.2	1.7	3.9	2.3	5.3	3.1	7.7	4.1	10.0	6.9	11.1	5.9
55–64	8.2	5.5	7.5	8.0	8.5	10.1	5.5	2.9	5.4	5.1	5.8	6.8	8.4	5.7	9.1	7.5	10.0	9.6
65–74	10.4	7.9	8.5	12.2	11.7	11.9	6.6	5.4	4.6	8.7	10.0	8.0	8.9	2.6	14.1	14.8	7.5	10.2

	Possible infarction																	
35–44	4.3	1.3	2.1	6.5	6.5	4.1	3.4	1.2	3.6	3.2	7.1	1.6	4.6	3.5	7.9	4.5	5.1	3.7
45–54	5.9	1.0	7.5	5.7	8.6	5.7	2.1	0.0	0.0	3.4	3.1	2.7	6.9	4.1	6.0	6.6	9.2	7.1
55–64	7.7	5.0	5.7	6.8	10.6	9.3	5.7	3.7	5.2	5.1	5.8	7.4	8.9	4.8	9.7	8.0	10.6	11.0
65–74	7.9	6.9	5.6	8.5	10.2	9.0	6.5	5.2	8.3	9.8	1.7	7.1	12.4	7.4	9.8	19.3	18.9	13.6
	Number observed																	
	Persistent cough and phlegm																	
35–44	87	3	7	21	51	5	29	2	0	10	16	1	143	10	10	27	89	7
45–54	157	1	12	47	89	8	46	0	3	21	19	3	213	4	22	51	123	13
55–64	332	7	43	127	114	41	146	5	34	32	51	24	132	5	19	30	49	29
65–74	190	9	38	67	35	41	93	11	18	31	12	21	85	13	14	17	14	27
	Chronic bronchitis																	
35–44	4	0	0	0	3	1	1	0	0	0	1	0	14	2	0	3	9	0
45–54	8	0	4	3	1	0	1	0	0	1	0	0	28	0	5	6	12	5
55–64	56	2	15	14	12	13	27	1	10	6	5	5	28	1	5	8	4	10
65–74	52	1	11	18	9	13	20	4	6	4	1	5	25	5	6	3	4	7
	Angina																	
35–44	36	5	2	5	14	10	11	0	0	4	4	3	84	8	10	17	30	19
45–54	103	10	12	19	31	31	24	2	4	4	7	7	126	11	20	24	47	24
55–64	305	33	46	65	48	113	113	11	21	18	13	50	95	13	14	16	18	34
65–74	253	41	41	46	16	109	116	43	10	15	6	42	56	5	13	13	4	21
	Possible infarction																	
35–44	52	3	4	16	19	10	17	1	3	3	8	2	61	9	11	12	17	12
45–54	116	3	21	24	41	27	16	0	0	6	4	6	114	11	12	23	39	29
55–64	284	30	35	55	60	104	119	14	20	18	13	54	101	11	15	17	19	39
65–74	191	36	27	32	14	82	114	41	18	17	1	37	78	14	9	17	10	28

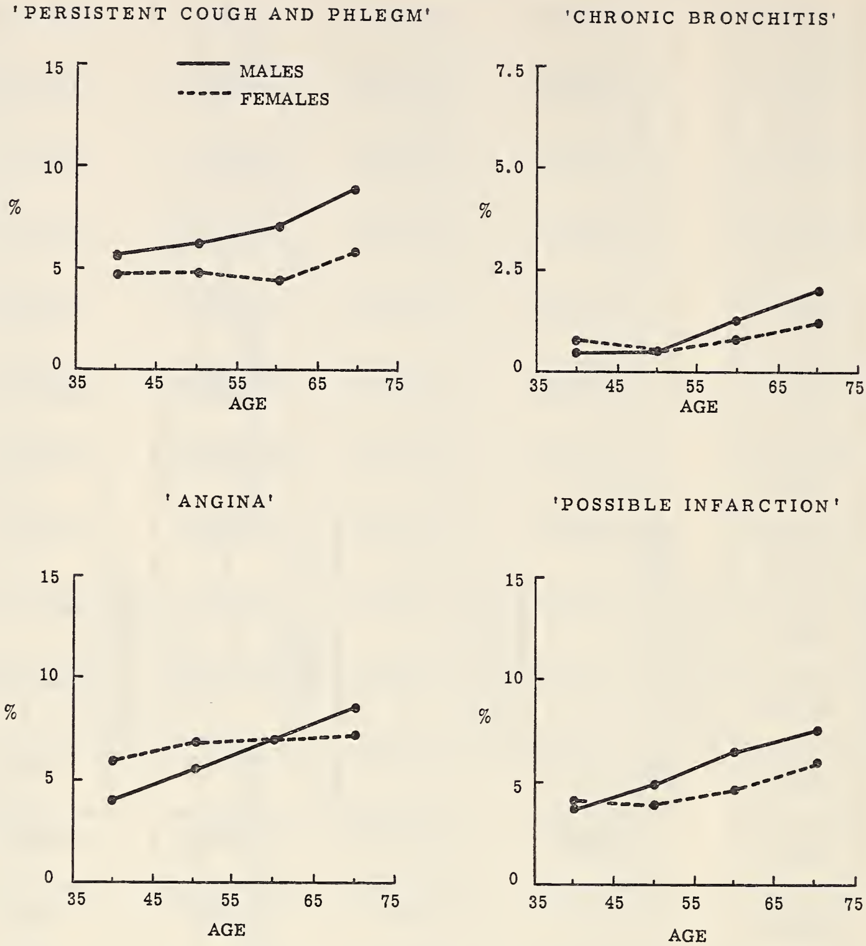
Table 8.—Number of persons with symptoms of persistent cough and phlegm, chronic bronchitis, angina, and possible infarction, with rate per 100 population, by sex, age, and smoking habits for British-, Norwegian-, and native-born. United States, 1962–63—Continued

b. FEMALES

Prevalence (percent)

Age at questionnaire	British-born						Norwegian-born						Native-born					
	Total	Never smoked	Current cigarette smoker (daily rates)			Ex-smoker	Total	Never smoked	Current cigarette smoker (daily rates)			Ex-smoker	Total	Never smoked	Current cigarette smoker (daily rates)			Ex-smoker
			<1 pack	1 pack	1+ pack				<1 pack	1 pack	1+ pack				<1 pack	1 pack	1+ pack	
	Persistent cough and phlegm																	
35–44	3.7	1.5	2.9	7.0	15.7	0.4	4.3	1.9	3.3	9.2	26.1	1.4	5.8	1.4	5.4	10.5	21.1	2.2
45–54	4.2	1.4	2.9	10.4	14.3	2.2	2.5	0.5	2.2	8.2	20.0	1.1	5.0	1.6	5.8	7.5	18.4	3.9
55–64	2.3	0.5	3.4	6.8	21.3	1.4	2.3	1.0	2.7	9.1	22.2	4.5	4.1	1.7	5.8	11.2	17.9	2.7
65–74	1.4	0.8	2.6	9.1	20.0	1.8	2.1	1.6	3.7	7.5	14.3	5.2	4.3	3.0	6.1	19.2	15.4	5.0
	Chronic bronchitis																	
35–44	0.6	0.6	0.3	0.0	4.5	0.0	0.6	0.0	0.0	1.3	4.3	1.4	0.9	0.3	1.4	0.7	2.4	1.1
45–54	0.4	0.0	0.5	0.7	0.9	0.4	0.3	0.3	0.0	1.4	0.0	0.0	0.8	0.4	1.1	1.2	2.7	0.4
55–64	0.6	0.2	0.4	1.4	6.7	0.7	0.5	0.3	0.0	3.4	3.7	0.9	0.7	0.4	0.6	0.0	3.6	1.8
65–74	0.5	0.3	0.9	3.6	0.0	0.6	0.8	0.6	1.8	2.5	0.0	1.3	1.2	0.9	3.0	3.8	0.0	1.7
	Angina																	
35–44	4.5	5.0	3.4	4.9	9.0	3.5	4.1	3.8	5.2	1.3	13.0	2.8	7.4	5.8	10.1	7.5	9.1	7.0
45–54	5.5	4.3	4.8	7.0	6.3	8.4	4.1	2.5	8.1	4.1	0.0	5.6	8.3	8.8	6.6	9.4	10.2	7.1
55–64	5.9	5.1	5.2	7.2	9.3	9.8	6.2	6.0	6.4	4.5	14.8	6.3	7.5	7.6	7.7	3.7	10.7	9.0
65–74	5.8	5.0	5.2	7.3	10.0	13.2	6.1	6.1	2.8	12.5	14.3	6.5	8.2	8.3	4.5	3.8	7.7	13.3

	Possible infarction																	
35–44	3.3	2.6	3.1	4.3	5.2	2.8	3.9	1.9	4.6	3.9	8.7	6.9	4.4	2.8	3.8	4.1	9.6	6.2
45–54	3.3	3.1	1.6	3.3	8.0	4.9	3.3	2.5	3.0	2.7	0.0	8.9	4.1	2.2	4.8	6.7	6.8	4.7
55–64	3.6	2.7	3.8	5.0	2.7	7.5	4.1	3.9	3.7	8.0	7.4	3.6	4.6	4.3	5.8	4.7	7.1	3.6
65–74	4.0	3.7	3.9	5.5	0.0	7.2	4.9	4.8	5.5	7.5	0.0	6.5	5.9	5.7	3.0	19.2	0.0	6.7
	Number observed																	
	Persistent cough and phlegm																	
35–44	71	8	18	23	21	1	23	4	5	7	6	1	112	11	20	31	44	6
45–54	71	9	13	28	16	5	17	2	3	6	5	1	90	12	22	19	27	10
55–64	60	8	17	15	16	4	36	11	6	8	6	5	46	12	9	12	10	3
65–74	29	13	6	5	2	3	36	24	4	3	1	4	31	17	4	5	2	3
	Chronic bronchitis																	
35–44	11	3	2	0	6	0	3	0	0	1	1	1	17	2	5	2	5	3
45–54	6	0	2	2	1	1	2	1	0	1	0	0	15	3	4	3	4	1
55–64	15	3	2	3	5	2	8	3	0	3	1	1	8	3	1	0	2	2
65–74	10	5	2	2	0	1	13	9	2	1	0	1	9	5	2	1	0	1
	Angina																	
35–44	86	27	21	16	12	10	22	8	8	1	3	2	142	45	37	22	19	19
45–54	94	28	21	19	7	19	28	9	11	3	0	5	150	68	25	24	15	18
55–64	157	79	26	16	7	29	97	68	14	4	4	7	85	53	12	4	6	10
65–74	116	77	12	4	1	22	104	90	3	5	1	5	60	47	3	1	1	8
	Possible infarction																	
35–44	62	14	19	14	7	8	21	4	7	3	2	5	85	22	14	12	20	17
45–54	56	20	7	9	9	11	23	9	4	2	0	8	74	17	18	17	10	12
55–64	96	42	19	11	2	22	65	44	8	7	2	4	52	30	9	5	4	4
65–74	81	57	9	3	0	12	84	70	6	3	0	5	43	32	2	5	0	4



Text-figure 2.—Prevalence of symptoms for persistent cough and phlegm, chronic bronchitis, angina, and possible infarction, adjusted for smoking habits, by sex and age.

Age-specific prevalence rates adjusted for smoking habits among the three nativity groups for the respective symptom categories are given in table 10. For persistent cough and phlegm, the age and sex patterns in prevalence within each nativity group conformed to the over-all experience described in table 7 and text-figure 2. The patterns for angina are similar, though the age gradient is somewhat less in evidence among native-born females than among the migrants. Norwegian-born and native-born males displayed age gradients in the prevalence of possible infarction, deviating from the over-all experience; the age curve for Norwegian-born males had a shallow slope while that for native-born males was steeper than the over-all trend line. This heterogeneity in the male results in possible infarction was in marked contrast to the experience for

females where all three groups tended to conform quite closely to the over-all pattern.

TABLE 9.—Symptom prevalence rates standardized for age, per 100 population by sex and current smoking habits for British-, Norwegian-, and native-born. United States, 1962–63

Smoking habits	Males			Females		
	British-born	Norwegian-born	Native-born	British-born	Norwegian-born	Native-born
	Persistent cough and phlegm					
Never smoked	1.3	1.3	3.6	0.9	1.3	1.9
<1 pack/day	6.3	6.7	12.4	3.1	3.0	5.7
1 pack/day	13.8	11.5	14.8	8.1	8.5	9.9
1+ pack/day	19.6	18.5	27.9	16.6	21.9	19.5
Ex-smokers	3.3	2.9	7.2	1.3	3.0	3.4
	Chronic bronchitis					
Never smoked	0.2	0.3	1.1	0.3	0.4	0.6
<1 pack/day	1.8	1.9	3.4	0.5	0.4	1.4
1 pack/day	1.7	1.2	2.8	0.8	1.7	1.0
1+ pack/day	1.6	1.2	3.2	3.5	2.3	2.7
Ex-smokers	0.9	0.5	2.2	0.4	0.8	1.1
	Angina					
Never smoked	5.5	3.7	4.6	4.9	5.4	7.7
<1 pack/day	6.4	4.3	10.8	4.4	5.9	7.8
1 pack/day	7.0	4.9	8.9	6.4	4.6	7.5
1+ pack/day	7.4	5.6	10.4	8.2	9.6	9.8
Ex-smokers	9.2	6.0	8.8	8.0	5.0	8.6
	Possible infarction					
Never smoked	4.5	3.6	6.0	3.0	3.7	4.0
<1 pack/day	5.5	5.2	8.5	3.0	3.9	4.6
1 pack/day	6.6	5.3	8.2	4.3	5.0	6.0
1+ pack/day	8.9	4.8	9.1	5.5	5.5	7.8
Ex-smokers	7.8	5.8	9.8	5.4	6.0	5.5

The investigation of the reasons underlying these differences may be furthered by examination of the prevalence rates among migrants classified by age at migration. These results are reviewed in table 11 and text-figure 3 in the form of standardized ratios adjusted for current age and smoking history. Unlike the rates previously given, the standardized ratios for males and females cannot be compared directly, since each was based on separate schedules of rates for each sex.

Differences between the four sex-nativity groups can be discerned. The British-born males show little evidence of consistent gradients in

TABLE 10.—Symptom prevalence rates standardized for smoking, per 100 population by sex and age for British-, Norwegian-, and native-born. United States, 1962–63

Age at questionnaire	Males			Females		
	British-born	Norwegian-born	Native-born	British-born	Norwegian-born	Native-born
	Persistent cough and phlegm					
35–44	7.2	6.1	10.8	3.7	5.2	5.5
45–54	8.0	6.9	12.7	4.1	3.1	4.9
55–64	8.5	7.7	11.6	2.2	2.9	3.6
65–74	7.1	6.4	12.4	1.5	2.4	3.9
	Chronic bronchitis					
35–44	0.3	0.2	1.0	0.6	0.7	0.8
45–54	0.4	0.1	1.6	0.4	0.4	0.9
55–64	1.5	1.3	2.6	0.6	0.6	0.6
65–74	1.9	1.4	3.7	0.5	0.8	1.1
	Angina					
35–44	3.0	2.2	6.3	4.5	4.2	7.3
45–54	5.2	3.3	7.6	5.5	4.2	8.3
55–64	8.2	5.4	8.4	5.9	6.2	7.4
65–74	9.9	7.0	8.8	5.7	6.2	8.1
	Possible infarction					
35–44	4.3	3.4	4.6	3.3	4.3	4.4
45–54	6.0	2.2	7.0	3.3	3.6	4.1
55–64	7.7	5.8	9.0	3.6	4.3	4.6
65–74	7.6	6.7	12.2	4.0	5.0	5.9

prevalence by age at migration for any of the symptom categories, although migrants arriving at age 30 or after appear to have lower prevalence rates. There is some indication of lower prevalence among British females who came to the United States after age 15 for persistent cough and phlegm, angina, and possible infarction. In contrast, both male and female migrants leaving Norway in adult life have consistently lower rates for persistent cough and phlegm, angina, and possible infarction.

The flow of migration from specific localities in Norway and Great Britain to the United States has varied over time, and the differentials in prevalence associated with age at migration may be indirectly linked with the characteristics of place of origin. The data on symptom prevalence are reviewed from this point of view in table 12 and text-figure 4. Both British and Norwegian males residing in rural areas before migration have lower prevalence rates for persistent cough and phlegm, angina, and possible infarction. Among female migrants, respiratory symptom

TABLE 11.—Prevalence ratios,* standardized for age and smoking habits, by sex and age at time of migration for British-born and Norwegian-born. United States, 1962–63

Age at migration (years)	Males				Females			
	British-born		Norwegian-born		British-born		Norwegian-born	
	Number with symptoms	Prevalence ratios*	Number with symptoms	Prevalence ratios*	Number with symptoms	Prevalence ratios*	Number with symptoms	Prevalence ratios*
Persistent cough and phlegm								
<15	276	91	101	112	94	87	41	96
15–29	339	96 } 93	185	79 } 75	89	55 } 54	60	74 } 68
30 and over	139	85 }	25	55 }	39	52 }	6	37 }
Chronic bronchitis								
<15	38	91	8	53	14	73	8	93
15–29	62	92 } 87	39	82 } 76	19	56 } 52	17	88 } 79
30 and over	19	73 }	2	29 }	6	41 }	1	29 }
Angina								
<15	223	103	65	85	158	90	77	96
15–29	345	113 } 105	179	74 } 70	190	68 } 68	143	78 } 75
30 and over	110	88 }	16	44 }	83	69 }	23	60 }
Possible infarction								
<15	221	105	65	89	100	91	52	101
15–29	307	106 } 100	170	74 } 73	134	72 } 70	112	94 } 93
30 and over	100	85 }	23	65 }	50	64 }	21	89 }

*100 = Rate for combined British-, Norwegian-, and native-born populations, ages 35–74.

TABLE 12.—Prevalence ratios,* standardized for age and smoking habits, by sex and place of birth for British-born and Norwegian-born. United States, 1962–63

Place of birth	Males				Females			
	British-born		Norwegian-born		British-born		Norwegian-born	
	Number with symptoms	Prevalence ratios*	Number with symptoms	Prevalence ratios*	Number with symptoms	Prevalence ratios*	Number with symptoms	Prevalence ratios*
	Persistent cough and phlegm							
Conurbations	361	100} 95	81	96} 88	92	78} 77	24	89} 100
Other urban	279	90}	64	80}	76	75}	28	112}
Rural	81	71	125	79	41	106	44	104
	Chronic bronchitis							
Conurbations	49	85} 85	13	85} 79	17	77} 71	10	172} 138
Other urban	44	85}	10	72}	12	63}	6	103}
Rural	15	77	19	64	10	133	3	31
	Angina							
Conurbations	332	118} 109	72	98} 88	202	97} 91	52	87} 96
Other urban	241	98}	55	79}	159	85}	60	106}
Rural	91	96	98	61	62	87	100	88
	Possible infarction							
Conurbations	269	100} 102	66	94} 85	121	89} 88	48	121} 112
Other urban	245	105}	51	76}	106	87}	38	102}
Rural	79	88	108	70	42	89	76	102

*100 = Rate for combined British-, Norwegian-, and native-born populations, ages 35–74.

prevalence is inconsistently related to place of origin. For angina, and to a limited extent for possible infarction, women coming from rural Norway have some small advantage.

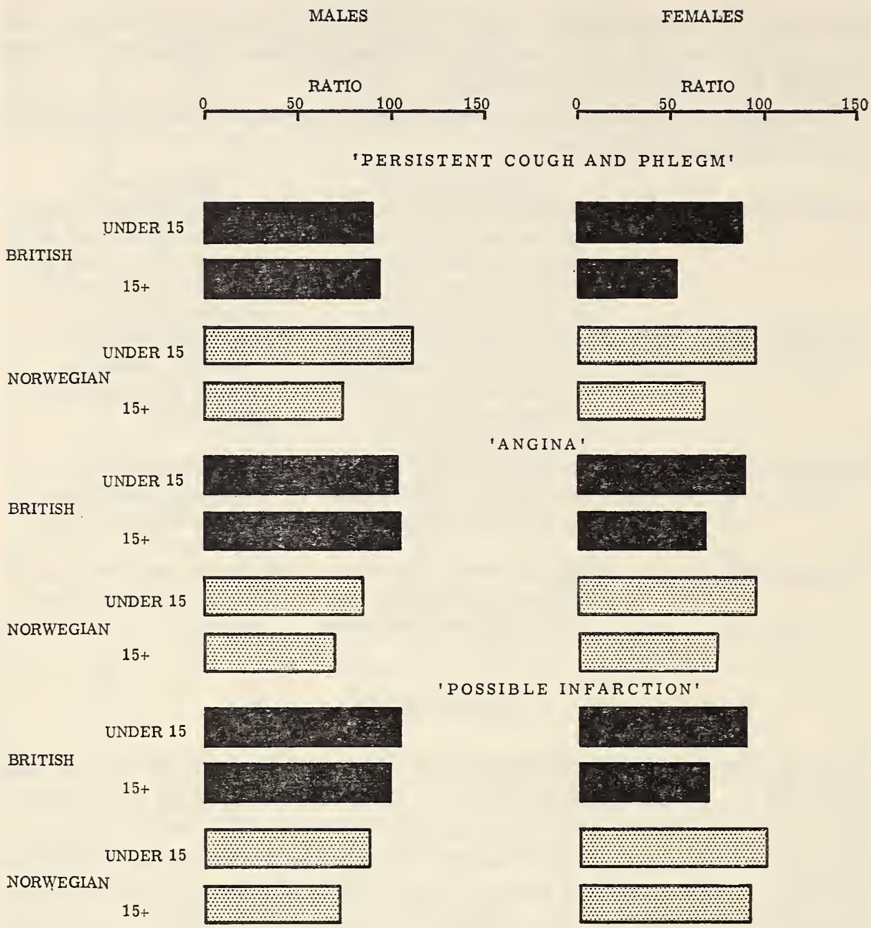
The gradients in risk with respect to age at migration and place of origin may be summarized as follows:

	Age at migration	Place of origin
British males	No consistent gradients in risk for any symptom categories, but those arriving at age 30 or after have lower prevalence rates	Lower prevalence among migrants from rural areas for persistent cough and phlegm, angina, and possible infarction
Norwegian males	Migrants arriving after age 15 have lower prevalence for persistent cough and phlegm, angina, and possible infarction	Lower prevalence in all symptom categories among migrants from rural areas
British females	Migrants arriving after age 15 have lower prevalence for all symptom categories	Higher prevalence of respiratory symptoms among migrants from rural areas
Norwegian females	Migrants arriving after age 15 have lower prevalence for all symptom categories	No major gradients in risk for any symptom categories

DISCUSSION

In this preliminary communication, the results were based on data collected by postal questionnaires on symptoms indicating the presence of chronic respiratory and cardiovascular disease. This might appear to be a crude method of data collection, of uncertain precision, and unproved validity. However, it is believed that self-administered questionnaires of this type have virtues beyond the obvious ones of simplicity of administration and economy in collection. It seems likely, for example, that the impersonal approach involved in a self-administered questionnaire excludes some of the variation associated with the differences between observers noted by Fairbairn *et al.* (*2*). Moreover, as Sharp *et al.* (*3*) have recently shown, such self-administered questionnaires produce, when given at intervals of some months, reasonably consistent replies about the presence of respiratory symptoms.

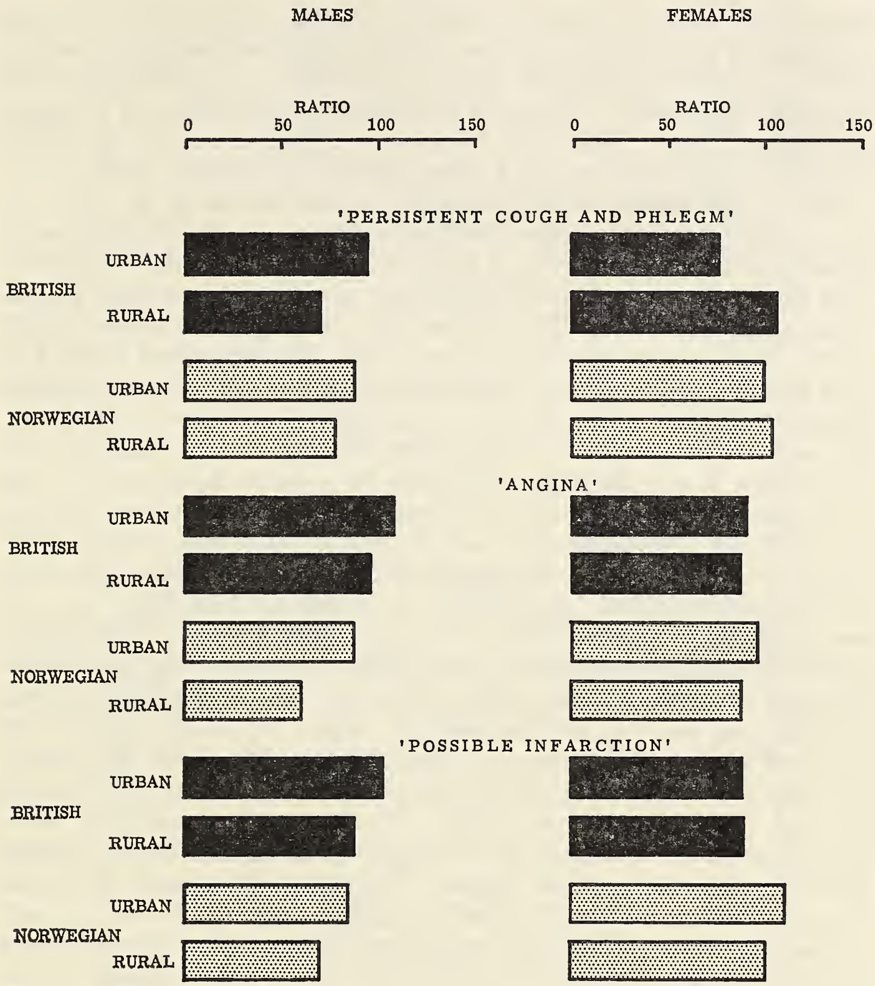
The validity of both the respiratory and cardiovascular components of the postal questionnaire used in this survey has been demonstrated by others. Although the questionnaire has usually been administered by clinical interviewers in the studies cited, it seems reasonable to expect that the general relationships hold for the self-administered form. It has been repeatedly shown that subjects with different degrees of respiratory disorder as elicited by the Medical Research Council Committee's questionnaire have a correspondingly graded lung function test performance (*4, 5*). Similarly, the cardiovascular syndromes of angina and possible infarction defined in terms of responses to the cardiovascular section of the question-



TEXT-FIGURE 3.—Prevalence ratios, standardized for age and smoking habits, for persistent cough and phlegm, angina, and possible infarction, by sex and age at time of migration for British-born and Norwegian-born. United States, 1962–63.

naire have been shown to be associated with electrocardiographic changes indicative of cardiac ischemia. A limited follow-up has disclosed higher rates of death and hospital admission for heart disease among those reporting the presence of these syndromes (*6*).

Although such indications of validity are encouraging, the utility of postal inquiry in symptom prevalence surveys depends on the internal consistency of the results and on their compatibility with evidence from clinical morbidity surveys or mortality data, as well as on the prognostic value as assessed by the follow-up. Respiratory symptoms might have, for example, age and sex and smoking-class relationships similar to those already found in prevalence surveys or in long-term mortality studies. If this type of agreement with independent reports were consistently found, more confidence could be placed on results obtained by this postal ques-



TEXT-FIGURE 4.—Prevalence ratios, standardized for age and smoking habits, for persistent cough and phlegm, angina, and possible infarction, by sex and place of birth for British-born and Norwegian-born. United States, 1962–63.

tionnaire about other aspects of health experience where no such external check is readily available.

If the respiratory findings are taken first, the results obtained in this study can be compared with those from other surveys in the United States. The only comparable published data come from studies in Berlin, New Hampshire (*7*), Detroit (*8*), Chicago (*3*), Jersey City (*9*), Tecumseh (*10*), and Eastern U.S. cities (*11*). Unfortunately, no strict comparison by age and sex groups for defined symptoms is practicable, but the level of the rates yielded by the current survey are in general agreement with those reported in studies where the questionnaire was administered by interviewer as well as impersonally. More important, however, is the consist-

ency of the evidence from these various studies on the age and sex distribution of respiratory symptoms and on their relationship to smoking habits. Another qualitative check is provided by comparisons with mortality experience. There is a male excess in mortality and a steeper gradient with age. Both these features are reproduced in our morbidity results for persistent cough and phlegm and for chronic bronchitis.

The cardiovascular symptom results can be compared, in the same way, with interview studies providing evidence on the distribution of ischemic heart disease in the U.S. population. Only one of these, however, uses the same conventions on syndromes based on the standard cardiovascular questionnaire. This is the study of telephone company staffs in the cities of the eastern seaboard (*12*). The age range covered in that study was 40 to 59 and the average rates can therefore be compared directly with those of the 45 to 54 age group in the current investigation. For angina the rates in the independent inquiries are 5.6 compared with 7.6 percent in the Migrant Study and for possible infarction, 7.6 and 7.0 percent, respectively. Reports from studies such as those in Framingham (*13*), or Tecumseh (*14*), use diagnostic conventions which differ from ours so that a direct comparison of the level of our rates with theirs will be uninformative. A qualitative comparison of smoking, age, and sex gradients is more revealing. In agreement with the Framingham results, our possible infarction rate is higher for males than for females, increases with age for both sexes, and shows a definite smoking gradient. The age and sex, but not the smoking, results are also consistent with those reported for Tecumseh (*14*) and Albany (*15*). Our age pattern for angina is consistent with that shown in these three studies, but the sex and smoking patterns are not. We find an approximately equal prevalence rate of anginal-like symptoms among the sexes, whereas Framingham reports a male excess. This may be accounted for by our inclusion of the less severe anginal symptoms, and these may be more frequently reported by female respondents. Our finding of a difference between cigarette smokers and those who have never smoked in the prevalence of anginal-like symptoms is in contrast to the incidence data from Framingham and Albany, but it is in agreement with incidence estimates based on physician consultations for persistent angina reported by Shapiro *et al.* (*16*)

The general level of morbidity indicated by the questionnaire results in the three nativity groups can be compared with the corresponding mortality rates given in table 13. The latter include the death rates from lung cancer, chronic nonspecific lung disease (bronchitis, bronchiectasis, and emphysema), and coronary heart disease in American residents born in the three countries.

The most striking and unexpected aspect of the present findings is the low level of respiratory symptoms reported by the British-born living in the United States. Indeed, for both persistent cough and phlegm and chronic bronchitis the reported prevalence is below that of the native-born. In contrast, residents of Great Britain appear to have a prevalence of chronic

TABLE 13.—Comparative morbidity and mortality from cardiorespiratory disease, Great Britain, Norway, and the United States, migrant and nonmigrant populations

	Males					Females				
	Residents of the United States			Residents of Great Britain	Residents of Norway	Residents of the United States			Residents of Great Britain	Residents of Norway
	Born in Great Britain	Born in Norway	Native-born			Born in Great Britain	Born in Norway	Native-born		
Chronic nonspecific lung disease:										
Mortality*	22. 8	9. 3	24. 2	125. 4	9. 7	4. 1	1. 8	3. 6	24. 0	3. 7
Morbidity†										
Persistent cough and phlegm	8. 1	6. 1	11. 0	—	—	2. 6	2. 4	4. 1	—	—
Chronic bronchitis	1. 2	0. 8	2. 3	9. 4	—	0. 5	0. 5	0. 8	3. 1	—
Lung cancer:										
Mortality*	93. 7	47. 5	72. 2	151. 2	30. 5	11. 5	10. 7	9. 8	19. 3	5. 6
Coronary heart disease:										
Mortality*	549. 3	510. 0	578. 8	426. 5	315. 5	195. 3	180. 3	196. 5	157. 7	112. 0
Morbidity†										
Angina	7. 3	5. 0	8. 5	—	—	5. 4	5. 5	7. 6	—	—
Possible infarction	6. 8	5. 0	7. 9	—	—	3. 4	3. 8	4. 3	—	—

*Average annual death rates per 100,000 population, ages 35–74, age-adjusted by the direct method to the U.S. population in 1940. For residents of the United States, 1959–61 data; for Great Britain and Norway, 1960–62 data. Lung cancer, ISC codes 162. 1, 163; CNSLD, codes 502, 526, and 527.1; CHD, codes 420, 422 (for Norway, includes the small additional parts of code 162 and 527). Data supplied by Vital Statistics Offices of the three countries.

†Percentage prevalence in specified U.S. population subgroup, ages 35–74 (Migrant Study), age-adjusted by the indirect method; for residents of Great Britain, percentage prevalence for ages 45–64 [College of General Practitioners' Survey (1958)]. Data from the two studies are not strictly comparable because of differences in definitions and methods; the effects of the differences, however, tend to be offsetting.

bronchitis which is several times that of native-born Americans. The mortality experience indicates that this low level among the British-born in the United States is not an artifact of symptom reporting. Age-standardized mortality from chronic nonspecific lung disease is virtually identical among the British- and native-born living in the United States, but less than one fifth that in Great Britain. This is true for both males and females. The experience of the Norwegian migrants with respect to respiratory disease conforms more nearly to expectation. Although quantitative comparisons with respect to respiratory symptoms according to the present diagnostic categories are not possible, it is known that respiratory disease is less prevalent in Norway than in Britain (*17*). Furthermore, the reported mortality from chronic nonspecific respiratory disease is only about half as high in Norway as among native-born Americans (table 13). These differences are reproduced in the findings on both symptom prevalence and mortality for Norwegian migrants, male and female. In view of the apparent decline, following migration, of the British prevalence and mortality from chronic nonspecific lung disease to or below American levels, it is particularly interesting that approximately one third of the difference in mortality from lung cancer between the two countries persists after migration (*See* p 346). The experience of discontinued smokers is relevant in this connection. For respiratory symptoms they most resemble nonsmokers (table 7), while for mortality from lung cancer they are intermediate between smokers and nonsmokers.

The predominant effect of present as opposed to past influence is also apparent in the experience of the British migrants with respect to coronary heart disease. Despite the one-fourth excess in mortality of males from coronary heart disease in the United States as compared with Great Britain, British- and native-born in the United States are subject to virtually identical mortality. The reported prevalence of symptoms suggestive of coronary disease for the British-born is below that of the native-born, but the differences seem small compared to the mortality difference between the two countries. The mortality experience of the Norwegian migrants is similar to that of the British. Despite an almost twofold American excess in mortality over that in Norway, the male migrants show only slightly lower mortality rates than the native-born, while the female migrants do not differ at all.

The interpretation of these results in migrant populations presents problems. Migrants may be subject to a number of selective factors, including the possible effects of medical examination and the migration of fitter people. It is not easy, however, to imagine factors which select, as with the British, for reduced respiratory but increased coronary disease. It is also quite possible that the migrant is less likely than the native-born American to report apparently trivial symptoms. But the remarkable disparity between death rates for British men living in the United States and for those in Great Britain itself is hardly likely to be thus explained. Nor, as already indicated, are differences in diagnostic habit likely to

account for such major contasts in mortality from the chronic lung disorders when taken as a broad grouping.

Changes in smoking habits after migration which would affect the prevalence of respiratory symptoms may take place, but we have as yet no evidence on this point. We do know from the present study, however, that the surprisingly low level of respiratory morbidity among British migrants is not because they have come mainly from rural areas. The simplest explanation is that their removal to the United States is followed by a reduction in symptoms and in an arrest in the progression of bronchitis and its allied diseases. On the other hand, it is also possible that structural lung damage received early in life, particularly in the British urban environment, may remain to cause the residual excess observed in lung cancer above the level found in the native-born.

It must be emphasized that these are tentative suggestions based on present information. Their elucidation must await the further investigations now in progress. Thus the information from relatives about British and Norwegian migrants dying in the United States will allow the relation of major disease to a wider range of factors than are covered either in routine mortality tabulations or in this report. It may also clarify the puzzling results on age at migration and place of origin. The comprehensive clinical information provided in this study by the certifying physician will allow multiple cause coding and a more precise description of the course of the fatal illness than is routinely possible. But the most fruitful source of information on the evolution of disease in migrants is likely to be the projected long-term study comparing the progress from current levels of morbidity to death among the migrants reported on here and among their siblings and the population samples in their country of origin.

SUMMARY

Preliminary results are reported from a survey by postal questionnaire of the prevalence of cardiorespiratory symptoms in samples of United States residents born either there or in Britain or Norway. Four syndromes are considered: "persistent cough and phlegm," "chronic bronchitis," "angina," and "possible infarction." The relation of smoking to the prevalence of these symptoms is clearly demonstrated, and the age : sex distribution of the more serious syndromes agrees with experience in U.S. field surveys and mortality data. There is a definite gradient in the prevalence in cardiac symptoms among males which reflects the ranking of coronary heart disease death rates in Norway, Britain, and the United States. Contrary to expectations based on the high death rate from respiratory disease in Britain, the prevalence rates for respiratory symptoms in British male migrants are no higher than those for native-born Americans. This finding, however, closely agrees with current mortality experience in these various groups in the United States. These results,

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and those for females where differences between the nativity groups are much less striking, are also discussed in relation to place of origin and age at migration.

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NCI Monographs, v. 19, 1966

Preconception, Intrauterine, and Postnatal Irradiation as Related to Leukemia [1]

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IN the past decade, a number of investigators have reported on the relationship between various kinds of exposure to radiation and childhood leukemia. Most of these papers have dealt with exposure of the fetus to diagnostic irradiation *in utero*, and, in addition, several have included data on diagnostic or therapeutic postnatal irradiation. Stewart *et al.* (*1*) found excess risks for children having intrauterine irradiation as well as for children with several postnatal exposures. Simpson and Hempelmann (*2*) and Polhemus and Koch (*3*) found excess risks for postnatal therapeutic, and diagnostic irradiation, respectively. In addition, MacMahon (*4*) and Ford, Paterson, and Treuting (*5*) found an excess risk for intrauterine irradiation.

Not all results have been positive. Thus, Court Brown *et al.* (*6*) found no difference in the risk for children irradiated *in utero*. Ager *et al.* (*7*) were unable to establish a significant difference in risk for either intrauterine or postnatal irradiation.

The studies reported have utilized a number of research designs. Comparison of cases with controls drawn from hospital populations has been the method most frequently used. Stewart compared deaths from leukemia with controls matched on age, sex, and residence from local birth registers. Simpson and Hempelmann (*2*) compared deaths from leukemia in individuals who had received therapeutic radiation with those occurring among untreated siblings and with expected numbers generated from reported mortality rates. Their roster of irradiated children was obtained from therapy records in hospitals and offices of radiologists. Ager *et al.* (*7*) compared radiation histories of leukemia cases from hospitals

[1] This research was supported by Public Health Service grant CS-9616.

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with sibling and neighborhood controls. MacMahon (*4*) compared cases obtained from death certificates in 9 States with a sample of children born in hospitals in these same States with respect to history of intrauterine X-ray exposure.

A number of factors have been identified in recent literature as being associated with both radiation history and subsequent development of leukemia, including pregnancy order, age of mother at birth of affected child, age of child, and other demographic variables. Only more recent papers, notably that of MacMahon (*4*), have analyzed the radiation experience of cases and controls with adjustment for some of these factors.

Because of the variety of study approaches and the frequent lack of control of variables that could influence the relationship of leukemia to radiation, conflicting positive and negative findings might have been anticipated. Needed was a study capable of controlling related variables, which was free from the bias attendant upon interview recall and the use of hospital-derived populations. The aim of the present study was to cover all of the cases reported from selected geographic areas of New York State and the majority of those from the Baltimore and Minneapolis-St. Paul standard metropolitan areas, and to compare them with controls derived from a probability sample of the same base populations. Histories of X-ray exposure were verified by examination of medical records. In addition, a sufficient number of cases were accumulated to allow the analysis to control for various factors that could affect the relationship between leukemia and radiation experience.

METHODS

A previous publication described in detail the design and conduct of this study (*8*).

Because of the comparatively low incidence of leukemia and the number of relationships to be examined, a large base population was required. This was obtained by use of all of the urban population centers and surrounding rural counties in New York State, exclusive of New York City, and the Baltimore and Minneapolis-St. Paul standard metropolitan areas, including suburban and rural populations. The plan was to interview as many as possible of the mothers of children with leukemia (up to age 15) reported during 1959–62. In New York State, the Department of Health Tumor Registry was the primary source of information on cases. Health officers throughout the State obtained permission for the interviews from attending physicians and admission of interviewers to hospital record rooms to verify the data reported on the interview. Lilienfeld devised a similar system with the cooperation of physicians in the Baltimore area. For his earlier study (*7*) described previously, Schuman had previously organized notification and interviewing procedures. These were continued for this study.

The diagnosis of 84.3 percent of the cases in this series was based on examination of bone marrow (*see* Appendix table A). Ten percent were diagnosed by blood smear alone or in conjunction with other methods. Appendix table B presents the distribution by histology of leukemia cases interviewed, as shown in the hospital record.

Random sample controls were used to compare with cases on such variables as social class, education, and radiation history, which could not be adequately studied with sibling or neighborhood controls. The random sample was based on a stratified selection of households. The study areas were stratified by census tracts in cities and enumeration districts in rural areas, and a proportionate quota of blocks or of enumeration districts was drawn from each stratum with an over-all sampling rate of about 1 in 3,000 individuals. Teams of clerks traveled over the sampled areas and made lists of all households. From these lists, the required number of households was randomly selected. When the interviewer ultimately visited the household, she made a random selection of children found there using a predetermined procedure that yielded the required number of controls.

The interviewing yielded 319 child cases and 884 child controls on whom all data were completed. A total of 14 percent of the cases could not be interviewed because they could not be located, because of language barriers, or because their physicians would not approve the interview. A 2.1 percent refusal rate was encountered for the cases and a 6 percent refusal rate for the controls.

Comparison of the 1960 census returns for the areas studied with the sample distributions on sex, race, and age shows relatively good agreement (table 1). This statement holds as well for the Minneapolis-St. Paul, Baltimore, and upstate New York areas, considered separately.

To increase the reliability with which these results might be interpreted, a 10 percent sample was reinterviewed by a different person. This check was carried on as interviewing was under way so that systematic interviewer's errors could be corrected and eliminated as the study progressed. Equally important, the amount of variation in responses on reinterview has served to indicate the relative reliability of the categories of responses. This has been considered in the interpretations.

Because the nurse-interviewers' predilection could bias the recording of responses, they were kept ignorant as to whether the parent of a child with leukemia or a control was being interviewed. This was the reason that personnel other than the interviewers selected sample households for subsequent interview visits. However, in a number of instances before the end of the interview, the interviewer had ascertained that the subject was indeed a case. To counteract this, data that could be verified in medical records, such as radiation experience, were validated by review of hospital, physicians', and dental records pertaining to all individuals.

Verification of records was a most important study component. Starting with hospitals and physicians named by the informants, we con-

TABLE 1.—Comparison of percent distribution by sex, race, and age: random sample and 1960 population census

Sex and race	Census (%)	Sample: Number	Sample: Percent
White male	46. 9	414	47. 5
White female	45. 1	383	43. 9
Nonwhite male	4. 0	38	4. 4
Nonwhite female	4. 0	37	4. 2
Total	100. 0	872*	100. 0
Age			
Under 5 years	36. 9	284	32. 2
<1	7. 3	43	4. 9
1	7. 5	41	4. 7
2	7. 5	60	6. 8
3	7. 3	70	7. 9
4	7. 3	70	7. 9
5–9 years	33. 8	300	33. 9
5	7. 2	57	6. 4
6	6. 9	68	7. 7
7	6. 9	55	6. 2
8	6. 6	62	7. 0
9	6. 2	58	6. 6
10–14 years	29. 3	300	33. 9
10	6. 1	57	6. 4
11	6. 1	75	8. 5
12	6. 2	56	6. 3
13	6. 2	60	6. 8
14	4. 7	52	5. 9
Total	100. 0	884	100. 0

*Excludes 4 males and 8 females whose race was not determined.

tacted physicians and hospital record rooms to obtain data on all radiation to which the subjects were exposed. The informants failed to recall or mention many of the diagnostic X-ray films, and from a sample of 200 subjects we estimated that 79.6 percent of the total diagnostic X-ray films in physicians' and dentists' records and 66.5 percent of those in hospital records were *not* mentioned in the interview. The reader may refer to (*8*) for additional details on this point.

The analysis of the case-control data has followed conventional lines in dealing with percentage differences, and a major part of the findings has been expressed in the form of relative risk statements. Control on relevant variables was achieved through subclassification and the calculation of relative risks for individual categories. Several methods for combining risks or percentage differences in subclasses into summary measures have been proposed. Two procedures were utilized in this study: one which weighted the percent differences in each subclass by $n_1n_2/(n_1 + n_2)$ following the Cochran technique (*9*), and the other which weighted the natural log of the several relative risks by the inverse of their variances, using Sheehe's procedure based on the work of Woolf (*10*) and Haldane (*11*). Both methods are essentially weighted averages and in practice yield similar estimates of over-all relative risk.

The relative risk estimates in this report have been based on the Woolf-Haldane procedures. The probability statements attached to the

relative risks or percent difference test the null hypothesis that the relative risk is unity, or the difference is 0. Probability values for both risk and percents were calculated. The Cochran values were more conservative and are presented in this report.

OBSERVATIONS

The findings to be presented in this report will deal with demographic characteristics of cases and controls, radiation exposure of parents prior to conception of cases and controls, intrauterine irradiation, postnatal irradiation, and combinations of these exposures.

Demographic Factors

Previous research suggested that leukemia cases may differ from controls on religion, social class, ethnic background, and some other population characteristics possibly associated also with radiation experience. In general, we found that some of the previously identified demographic characteristics were important, although in more complex ways than hitherto described.

The findings in this study generally reflected earlier results that showed a higher proportion of males in the leukemia series—56.7 percent versus 51.6 percent for controls. In addition, there was a smaller proportion (5.3%) of nonwhites among cases than among controls (9.9%). Cases also presented a younger age distribution than controls, with an increased frequency under 5 years (table 2).

TABLE 2.—Age of cases at diagnosis and age of controls at interview

	Cases		Controls	
Age	Number	Percent	Number	Percent
0	18	5. 6	43	4. 9
1	36	11. 3	41	4. 7
2	41	12. 9	60	6. 8
3	53	16. 6	70	7. 9
4	42	13. 2	70	7. 9
5	26	8. 2	57	6. 4
6	15	4. 7	68	7. 7
7	17	5. 3	55	6. 2
8	10	3. 1	62	7. 0
9	7	2. 2	58	6. 6
10	9	2. 8	57	6. 4
11	17	5. 3	75	8. 5
12	12	3. 8	56	6. 3
13	14	4. 4	60	6. 8
14	2	0. 6	52	5. 9
Total	319	100. 0	884	100. 0

Earlier findings on socioeconomic status as related to leukemia conflict. For example, the British Registrar General (*12*) found a somewhat higher leukemia mortality rate in the upper socioeconomic strata, but the study by Graham, Levin, and Lilienfeld (*13*) revealed no such relationship. In the present research, with a 6-class system of occupational categories for urban workers plus a seventh for agriculture workers, no interesting differences between cases and controls were uncovered. Inasmuch as education is closely correlated with socioeconomic status, we would expect no relationship between educational level and leukemia. This was indeed the case. MacMahon's study of birthplace of *both child and adult* leukemia patients (*14*) suggested over-representation of persons born in Poland and Russia in the case series. An analysis of birthplace of parents of children in the present study showed no noteworthy difference in the distribution by country of birth.

MacMahon (*14*) also suggested an excess risk for Jews. In the present series, 3.8 percent of the cases were Jews compared to 6 percent for the controls. MacMahon did not distinguish the ethnic and religious derivation of childhood and adult cases. Our analysis of adult leukemias, to be elaborated in another publication, did show the relation reported by MacMahon: an excess of Jews and Russians in the case series.

Birth Characteristics

A comparison of ages of mothers at birth of children with leukemia and control children revealed essentially no difference:

Age of mother (years)	Cases (%)	Controls (%)
Under 20	5.4	8.0
20–24	29.5	27.0
25–29	26.6	27.5
30–34	23.9	20.2
35–39	11.2	12.7
40 and over	3.4	4.6

Table 3 reveals a small difference in the percentage of mothers of cases and controls who experienced miscarriage or stillbirth prior to the birth of the subjects (adjusted for year of birth, age of mother, and birth or pregnancy order). These differences lead to an estimated excess relative risk of 1.44 or 1.62 for mothers who experienced miscarriage and stillbirth, depending on the precise nature of the adjustment.

MacMahon's (*15*) exhaustive examination of birth order indicated that firstborn children bulked larger in his leukemia series than in his controls. On the other hand, Manning and Carroll (*16*) and Ager *et al.* (*7*) found an excess of first births in controls. Our sampling scheme, while random for household units, resulted in a larger proportion of firstborn among the controls than would have been expected on the basis of New York State vital statistics. For this reason our findings cannot be compared with MacMahon's. As table 4 shows, our results resembled

TABLE 3.—Adjusted percent of mothers experiencing miscarriage or stillbirth prior to birth of cases and controls and estimated relative risks of leukemia

Adjusted for:	Cases Number*	Cases Percent	Controls Number*	Controls Percent	Percent difference	Relative risk	Probability
1) Year of birth, age of mother, and birth order	315	23. 0	865	16. 7	6. 3	1. 62	. 014
2) Year of birth, age of mother, and pregnancy order	315	22. 4	865	18. 7	3. 7	1. 44	. 143

*Numbers presented in this and succeeding tables will not always agree with the respective totals for cases and controls of 319 and 884 in table 2 because of missing data for study variables.

TABLE 4.—Firstborn among leukemia cases and controls by year of birth of subject

Year of birth	Firstborn Number Cases	Firstborn Number Controls	Firstborn Percent Cases	Firstborn Percent Controls	Total Cases	Total Controls
1945–49	25	79	52. 1	33. 8	48	234
1950–54	29	128	35. 8	43. 4	81	296
1955–62	47	170	25. 3	50. 3	186	338
Total	101	377	32. 1	43. 4	315	868

MacMahon's for children born up to 1950, that is, a larger proportion of firstborn among the cases. From 1950 on, however, our controls, like those of Ager *et al.* (*7*) and Manning and Carroll (*16*), have the larger proportion of firstborn. Because of the possible relationship of birth order to leukemia, analyses which could involve this factor, such as preconception and intrauterine radiation, have been adjusted for birth order.

To summarize, comparisons of leukemia cases and the random sample controls were similar with respect to socioeconomic status, birthplace and religion of mother, and education of father. Differences were noted, however, in age of subject, miscarriage or stillbirth experience of mother prior to birth of subject, and birth or pregnancy order; thus, it was deemed necessary to adjust for these variables in the following presentations on radiation exposure.

Preconception Irradiation of Mothers

Table 5 shows the adjusted percent irradiated for cases and controls and the relative risk of leukemia, related to diagnostic radiation experience of mothers prior to conceiving cases and controls. We measured the time of conception by comparing the mother's statement as to how long she was pregnant with the subject's date of birth. It should be emphasized that these analyses covered all types of preconception diagnostic

radiation, including 18 cases (5.6%) and 34 controls (3.8%) whose mothers had fluoroscopy before conception. Mothers of 3 cases and 9 controls had therapeutic radiation, which was not included in the above-mentioned analyses. One mother had received radium implantation, but none had received radioisotopes of any kind.

TABLE 5.—Adjusted percent of mothers exposed to diagnostic radiation before conceiving cases and controls and estimated relative risks of leukemia

	Cases		Controls				
Adjusted for:	Number	Irradiated (%)	Number	Irradiated (%)	Difference (%)	Relative risk	Probability
1) Year of birth, age of mother, and birth order	313	46. 0	853	36. 4	9. 6	1. 55	0. 003
2) Year of birth, age of mother, and pregnancy order	313	46. 2	853	36. 5	9. 7	1. 56	0. 003
3) Year of birth, age of mother, and miscarriages or stillbirths	313	46. 7	852	36. 2	10. 5	1. 60	<0. 001
4) Age of mother, miscarriages or stillbirths, and birth order	313	47. 1	852	34. 0	13. 1	1. 73	<0. 001
5) Age of mother, miscarriages or stillbirths, and pregnancy order	313	46. 9	852	34. 1	12. 8	1. 73	<0. 001

These data are adjusted for various combinations of factors that, as shown in the last section, may possibly be associated with leukemia or preconception radiation. It would have been preferable to adjust for all factors simultaneously, but limitations imposed by the available number of cases and controls would permit adjustment on no more than 3 factors at a time. There was a 9.6 percent excess of cases exposed to diagnostic radiation, with a probability of 0.003 and a mean weighted relative risk of 1.55. Line 2 (table 5) shows similar findings weighting for year of birth, age of mother, and pregnancy order. Table 6 also reports on the effects of radiation, excluding that to the teeth, adjusted for year of birth, age of mother, and, respectively, birth order, pregnancy order, and prior miscarriage or stillbirth. This was of interest because of the possibility that radiation to parts of the mother's body close to the abdomen might be related to higher risk of leukemia in the offspring. Because individuals receiving dental radiation were excluded, the numbers of cases and controls are reduced. Such reductions will also be encountered in later analyses of subgroups of special interest. The results, relative risks of about 1.6, are in line with those presented in table 5 for mothers receiving preconception diagnostic radiation to any site.

Adjustment for year of birth, age of mother, and prior miscarriages or stillbirths (table 5) produced little change in relative risks for exposure to preconception radiation to any site, including the head and neck. The suggestion that the relative risk was somewhat enhanced by control-

TABLE 6.—Relative risks of leukemia associated with diagnostic radiation to abdomen, chest, or extremities of mothers before conceiving

Adjusted for:	Cases	Controls	Relative risk	Probability
1) Year of birth, age of mother, and birth order	277	780	1. 59	0. 006
2) Year of birth, age of mother, and pregnancy order	277	780	1. 59	0. 006
3) Year of birth, age of mother, and previous miscarriages or stillbirths	277	780	1. 66	0. 001

TABLE 7.—Relative risks of leukemia associated with preconception diagnostic radiation of mothers by selected characteristics, adjusted for age of mother and year of birth of subject

Characteristics of mother	Cases	Controls	Relative risk	Probability
1) Mothers of subjects who were issue of *first pregnancy*				
With radiation	24	103	0. 97	0. 66
Without radiation	60	237		
2) Mothers of subjects who were issue of *second or later pregnancy*				
With radiation	126	179	1. 63	0. 006
Without radiation	103	333		
(*a*) Pregnancy preceded by miscarriage or stillbirth				
With radiation	41	57	1. 41	0. 25
Without radiation	32	83		
(*b*) Pregnancy not preceded by miscarriage or stillbirth				
With radiation	85	122	1. 66	0. 02
Without radiation	71	250		
(*c*) Pregnancy preceded by both preconception radiation and miscarriage or stillbirth	41	57	1. 77	0. 05
With neither	71	250		

ling for both prior history of miscarriages or stillbirths and pregnancy order led to the analysis of risk by pregnancy order and history of previous fetal death (table 7). Line 1 in table 7 indicates no increased risk from preconception radiation among the issue of first pregnancies, controlling for mother's age at birth of subject and year of his birth. Line 2, however, shows a significant relative risk of 1.63 for preconception radiation among offspring from a second or late pregnancy. Whether these prior pregnancies had involved a stillbirth or miscarriage appeared to affect the risk but little (lines 2a–c). It is possible, then, that preconception radiation has an effect primarily among second or later pregnancies. Prior experience of miscarriage or stillbirth may not enhance this risk.

A supplementary review of mothers who had received radiation to the abdomen, pelvis, spine, or femur only, was carried out, unadjusted for

any factors because of the small number involved. It was found that 38 case and 52 control mothers, or 12.1 and 6.1 percent, respectively ($P < 0.001$), had experienced such preconception radiation, and the estimated risk of leukemia among children whose mothers had received such radiation, relative to those whose mothers had not, was 2.1.

All of the preceding analyses were carried out by comparing cases and controls with respect to mothers who did or did not receive preconception diagnostic radiation. It was deemed instructive, in addition, to contrast the children whose mothers had received preconception radiation against those who had received no radiation whatsoever, either preconception on the part of parents, or subsequent intrauterine or postnatal radiation. This was undertaken, adjusting for year of birth of subject, age of mother at time of birth, and pregnancy order, and yielded a relative risk of 1.51, of the same order as those already reported. Radiation to sites other than the teeth was similarly analyzed and produced an estimated relative risk of 1.5.

The finding of high risk for preconception radiation suggested that the risk might vary by the length of the interval between irradiation and conception. However, the need to consider numbers of exposures in combinations of years before conception resulted in such small numbers in subcategories that it was impossible to draw any conclusions as to the presence or absence of a gradient of risk related to exposure in years prior to conception.

Inquiry into the numbers of diagnostic X-ray films experienced by mothers of cases as compared to controls before their conception indicated (table 8) a higher risk for most exposure categories from 1 to 5 films up to 21 or more films, but no clear-cut dose-response relationship could be demonstrated.

Preconception Irradiation of Fathers

The finding that preconception irradiation of the mother was related to a higher risk of subsequent development of leukemia in the offspring raised the question whether irradiation of the father also carries an excess risk. An examination of the data, adjusted for year of birth of the subject, age of father at birth, and pregnancy order, showed that 26.3 percent of cases' fathers, as compared to 22.4 percent of controls' fathers, had received preconception radiation, which yielded a relative risk of 1.31 (table 9). In this analysis children whose fathers had received radiation before their conception were compared to those whose fathers had had no preconception radiation, regardless of whether their mothers had received preconception radiation, or they themselves had had either *in utero* or postnatal radiation. However, analysis comparing children whose fathers had had preconception radiation with individuals who had been subjected to no type of radiation produced similar results.

As with mothers, we also examined the risk of leukemia in offspring according to the number of films to which the father was exposed. As

TABLE 8.—Distribution of mothers by number of diagnostic X-ray films before conceiving children and estimated relative risks of leukemia

	0		1–5		6–10		11–15		16–20		21 and over		Number of films not known		Total	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Cases	163	52. 1	68	21. 7	23	7. 3	10	3. 2	15	4. 8	22	7. 1	12	3. 8	313	100. 0
Controls	571	66. 7	124	14. 5	42	4. 9	27	3. 2	19	2. 2	30	3. 5	41	4. 8	854	100. 0
Relative risk	0. 54		1. 6		1. 5		1. 0		2. 2		2. 1		0. 79		1. 00	

TABLE 9.—Adjusted percent of fathers exposed to diagnostic radiation before conception of cases and controls and estimated relative risks of leukemia

	Cases		Controls				
Adjusted for:	Number	Irradiated (%)	Number	Irradiated (%)	Difference (%)	Relative risk	Probability
Year of birth, age of father, and pregnancy order	310	26. 3	853	22. 4	3. 9	1. 31	0. 16

TABLE 10.—Distribution of fathers by number of diagnostic X-ray films before conception of children and estimated relative risks of leukemia

	0		1–5		6–10		11–15		16–20		21 and over		Number of films not known		Total	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Cases	228	74. 3	32	10. 4	13	4. 2	7	2. 3	6	2. 0	16	5. 2	5	1. 6	307	100. 0
Controls	654	78. 6	63	7. 6	28	3. 3	19	2. 3	15	1. 8	25	3. 0	28	3. 4	832	100. 0
Relative risk	0. 73		1. 4		1. 3		1. 0		1. 1		1. 8		0. 48		1. 00	

TABLE 11.—Percent of fathers and/or mothers exposed to diagnostic radiation prior to conception of cases and controls adjusted for year of birth, age of mother at birth, and pregnancy order and estimated relative risks of leukemia

	Cases		Controls				
	Number	Irradiated (%)	Number	Irradiated (%)	Difference (%)	Relative risk	Probability
Father and/or mother	306	54. 3	826	45. 3	9. 1	1. 47	0. 006
Father *and* mother	306	18. 2	826	14. 4	3. 8	1. 49	0. 121

table 10 shows, the percentages of fathers experiencing various numbers of X-ray films prior to conception of the children with leukemia exceeded the corresponding figures for controls. In addition, the distinctive contrast between the two extremes revealed for mothers was repeated for fathers. It should be pointed out that the number observed is small. As was noted for mothers, there was no excess of fathers receiving therapeutic radiation or fluoroscopy before conception of the child with leukemia.

The significantly high relative risk, approximately 1.6 for children whose mothers were irradiated before conception, accompanied by a smaller excess risk, about 1.3, of borderline significance for fathers, suggested the desirability for the investigation of the risk for children whose fathers and/or mothers had received preconception radiation. This particular group had a relative risk of 1.47 (table 11). When these children were compared with children whose parents had experienced no radiation and who themselves had not experienced *in utero* or postnatal radiation, the relative risk remained substantially unaltered.

To see whether an additive effect of radiation to both parents could be detected, a relative risk was calculated for children whose 2 parents had been irradiated. When these children were compared to the remainder of the population, the resulting weighted relative risk was 1.49, about the same order of magnitude as for children whose mothers alone had received radiation.

Intrauterine Radiation

Our data included too few mothers who had received abdominal radiation during pregnancy—27 cases and 54 controls—to conduct the desired analysis in detail. Previous studies have shown both greater and smaller percentages for mothers of controls receiving abdominal radiation, *e.g.*, 7.2 percent for Stewart's (*1*), 10.6 percent for MacMahon's (*4*), and about 3 percent for Murray *et al.* (*17*) as compared with 6.3 percent for the present study. Changes in physicians' practice regarding irradiation of pregnant women may have occurred in the interim since the earlier studies were reported and may be reflected in the smaller percentage of mothers in our series who received abdominal radiation. Another point to be noted is that our controls and Hempelmann's were drawn from rural and urban populations, a sizable proportion of whom would not have received medical care in the type of large metropolitan hospitals included in MacMahon's material. Nevertheless, we examined to the extent possible the association of leukemia with abdominal radiation for 2 time periods and the possible variation in this with year of birth of subjects. Table 12 shows a relative risk of leukemia of 1.35 for children born between 1945 and 1954, the period during which MacMahon's (*4*) cases were born, and a risk of 1.48 for subjects born after 1954. No significance should be attached to the difference in risk noted for the 2 periods.

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TABLE 12.—Percent of mothers exposed to abdominal radiation during pregnancy with cases and controls by year of birth and estimated relative risks of leukemia

Subject's year of birth	Cases		Controls		Relative risk
	Number	Irradiated (%)	Number	Irradiated (%)	
1945–54	128	8.6	522	6.5	1.35
1955–62	185	8.6	332	6.0	1.48
1945–62	313	8.6	854	6.3	1.40

Considering radiation to all sites, rather than to the abdomen alone (table 13), we compared the exposure of mothers while cases and controls were *in utero*, adjusting for combinations of year of birth, age of mother at birth, birth order, and pregnancy order. Adjusting for two variables as in lines 1, 2, and 3, we found that the relative risk of leukemia for those exposed to intrauterine radiation ranged around 1.4. Controlling for 3 variables, year of birth, age of mother, and pregnancy order, led to similar relative risks not greatly different from those found by Stewart (*1*) and MacMahon (*4*).

The preceding tables compared children irradiated *in utero* with all other children. Another comparison, not attempted in other studies, was that between children irradiated *in utero* and those who had no other radiation history whatsoever, neither to parents prior to conception nor to themselves postnatally. Controlling for year of birth, age of mother at the time of birth, and pregnancy order, we estimated this relative risk to be 1.44, in line with the findings already noted.

As a further test, it was useful to investigate the extent to which the relationship persists within various subgroups. Table 14 indicates no difference in relative risk from intrauterine radiation between issue of first and second or later pregnancies, adjusted for year of birth and age of mother. For children whose mothers had had miscarriages or stillbirths, the estimated risk was somewhat higher (1.81). Contrasting mothers having had both intrauterine radiation *and* prior fetal death with those experiencing neither yielded a relative risk of 2.2.

We were concerned, also, with the effect of radiation on leukemia risk by trimester of pregnancy in which the exposure was received. While the differences by trimester were small (table 15), estimated risks in the later trimesters were somewhat larger than in the first.

An analysis of the extremely small number of mothers receiving special forms of radiation (pelvimetry, 15 cases; fluoroscopy, 2; therapeutic radiation, 2) during pregnancy was inconclusive. A relative risk of 2.0 associated with pelvimetry rested on a case-control contrast of 15 cases (4.8%) versus 21 controls (2.5%).

Postnatal Irradiation

Previous findings on postnatal exposure of children to radiation as related to risk of leukemia have differed. Stewart (*1*) and Simpson

TABLE 13.—Adjusted percent of mothers irradiated during pregnancy with cases and controls and estimated relative risks of leukemia

Adjusted for:	Cases		Controls		Difference (%)	Relative risk	Probability
	Number	Irradiated (%)	Number	Irradiated (%)			
1) Year of birth and age of mother	313	29. 3	853	23. 9	5. 4	1. 42	0. 067
2) Year of birth and birth order	313	29. 5	853	23. 8	5. 7	1. 40	0. 053
3) Year of birth and pregnancy order	313	29. 4	853	23. 5	5. 9	1. 42	0. 044
4) Year of birth, age of mother, and birth order	313	30. 1	853	22. 5	7. 6	1. 56	0. 009
5) Year of birth, age of mother, and pregnancy order	313	30. 3	853	22. 4	7. 9	1. 59	0. 006

Table 14.—Relative risks of leukemia associated with intrauterine radiation and miscarriages or stillbirths; by pregnancy order, adjusted for age of mother and year of birth

Study groups	Cases	Controls	Relative risk	Probability
1) Subjests who were issue of *First pregnancy*				
With radiation	27	81	1.63	0.12
Without radiation	57	259		
2) Subjects who were issue of *Second or later pregnancy*				
With radiation	69	101	1.62	0.02
Without radiation	160	411		
(*a*) Pregnancy preceded by miscarriage or stillbirth				
With radiation	24	29	1.81	0.10
Without radiation	49	111		
(*b*) Pregnancy preceded by both intrauterine radiation *and* miscarriage or stillbirth	24	29	2.2	0.02
By neither	111	300		

Table 15.—Percent of mothers exposed to radiation during pregnancy with cases and controls by trimester of pregnancy and estimated relative risks of leukemia

Trimester	Cases irradiated (%)	Controls irradiated (%)	Relative risk
First	5.8	4.9	1.20
Second	8.8	5.0	1.82
Third	13.3	9.4	1.47

and Hempelmann (*2*) found suggestions of an excess risk, but Ager *et al.* (*7*) reported no difference. In our study, we were confronted with the problem of distinguishing radiation associated with leukemia from that received prior to the onset of leukemia or conditions related to its onset. We examined records of radiation received within 6 months before diagnosis of leukemia and found that it was largely associated with the disease or probably related conditions. It appeared, however, that radiation received more than 6 months before diagnosis was not related to the presence of leukemia.

To be conservative in our analyses, we excluded radiation exposure of cases received in the 6 months before diagnosis and of controls in the 6 months prior to interview. As further insurance, we repeated the same analyses including only that radiation received more than 12 months before diagnosis (cases) or interview (controls). Table 16 shows the results with respect to radiation of various sites up to 6 and 12 months before diagnosis or interview, with adjustments for differences in the age and sex distributions of cases and controls. No analysis of the effects of therapeutic radiation was possible here because only 2 cases and 5 controls had records indicating such exposure.

TABLE 16.—Relative risks of leukemia associated with postnatal radiation of the child, excluding that within 6 or 12 months of diagnosis or interview of case or control, by sites irradiated; adjusted for age and sex of child

Type of experience	Cases excluding last		Controls excluding last		Relative risk excluding last		Probability excluding last	
	6 months	12 months	6 months	12 months	6 months	12 months	6 months	12 months
No postnatal radiation versus:	226	238	566	598				
Radiation:								
1) Any postnatal	93	81	318	286	1. 19	1. 14	0. 38	0. 56
2) Chest only	19	20	62	61	1. 08	1. 11	0. 60	0. 77
3) Extremities only	10	8	54	42	0. 92	0. 98	0. 33	0. 44
4) Teeth only	28	23	120	103	1. 38	1. 42	0. 27	0. 29
5) More than one site	33	28	67	65	2. 1	2. 1	0. 003	0. 01
6) Chest and other site(s)	27	22	60	51	1. 98	2. 0	0. 02	0. 03
7) Abdomen and other site(s)	13	10	25	22	2. 1	1. 96	0. 11	0. 19
8) Extremities and other site(s)	13	13	31	36	1. 81	1. 75	0. 13	0. 25
9) Teeth and other site(s)	19	18	31	35	3. 2	2. 8	<0. 001	<0. 001

The two sets of relative risks (6 and 12 months) yielded generally consistent results. There was no impressive difference between cases and controls with regard to postnatal radiation *in toto*, and the relative risk, though pointing in the direction indicated by Stewart and others, was far from significant.

The risks for individuals receiving radiation to the chest only, extremities only, and teeth only revealed nothing of interest (table 16). Because of the small numbers of subjects, it was impossible to examine the risks for irradiation of the abdomen only. There was a larger relative risk for irradiation of the chest in combination with other sites up to 6 or 12 months before diagnosis.

Other suggestive findings include excess risks for irradiation of teeth and other sites and relative risks of 2 or better generally for irradiation of more than one site. There would appear to be a somewhat larger and significant risk associated with irradiation of multiple sites. Nevertheless, in view of the fact that only about 9 percent of cases and 5 percent of controls had this experience, such irradiation could account for only a small fraction of the total leukemia risk.

Table 17 shows a comparison of individuals who received some postnatal radiation with those receiving none. Individuals who received intrauterine or preconception radiation are excluded. Some individuals with no postnatal radiation had been irradiated *in utero*, or had parents who were irradiated prior to their conception. Inquiry into the question, excluding these other forms of exposure, enhanced the relative risks somewhat, but otherwise the results were consistent with those reported in table 16.

Postnatal radiation by number of films was reviewed in table 18. When children were classified by exposure to 1 to 5, 6 to 10, or 11 or more films, no statistically significant excess risks were uncovered and no dose-response relationship was suggested. When the analysis was limited to individuals who had been irradiated at 2 or more sites, the relative risks were larger, but again no dose-response relationship was evident.

Our attempt to examine the possible relationship between age at exposure to postnatal diagnostic radiation and leukemia risk was fruitless because of small numbers and the problems inherent in the study of exposures in multiple years.

TABLE 17.—Relative risks of leukemia associated with postnatal irradiation of the child, excluding that within 6 months of diagnosis or interview of case or control, by sites irradiated; adjusted for age and sex of child

Type of experience	Cases	Controls	Relative risk	Probability
No postnatal, intrauterine, or preconception radiation versus:	71	254	—	—
Radiation:				
1) Any postnatal	92	318	1. 3	0. 12
2) More than one site	33	67	2. 3	0. 001
3) Chest and other site(s)	27	60	2. 2	0. 005
4) Abdomen and other site(s)	13	23	2. 2	0. 06
5) Teeth and other site(s)	19	31	3. 8	<0. 001

TABLE 18.—Relative risks of leukemia associated with postnatal irradiation of the child, excluding that within 6 months of diagnosis or interview of case or control, by number of films; adjusted for age and sex of child

Type of experience	Cases	Controls	Relative risk	Probability
No postnatal irradiation versus:				
1) 1–5 films to 1 or more sites	283	745	1. 34	0. 23
2) 6–10 films to 1 or more sites	241	618	1. 40	0. 51
3) 11+ films to 1 or more sites	238	626	0. 83	0. 01
4) 1–5 films to 2 or more sites	237	580	2. 6	0. 03
5) 6–10 films to 2 or more sites	234	586	1. 91	0. 24
6) 11+ films to 2 or more sites	233	593	1. 50	0. 62

Combinations of Radiation Exposure

The finding of higher risks of leukemia associated with preconception irradiation of parents, intrauterine irradiation, and postnatal irradiation to multiple sites suggests the need to examine risks for various combinations of radiation. In table 11, relative risks for individuals whose 2 parents were irradiated prior to their conception were considered.

Table 19 presents data bearing on other combinations of radiation experience, including children irradiated *in utero*, whose mothers were exposed before their conception, or who had one or both parents exposed prior to their conception. Persons who had intrauterine exposure and who had either one or both parents irradiated prior to conception showed a high and significant relative risk when compared with persons who had received no irradiation.

Other combinations of exposure included postnatal with parental radiation, the latter received *in utero* or prior to conception, and any of the three types—preconception radiation of father and/or mother, intrauterine, and postnatal. Table 19 shows that these combinations did not yield significantly high relative risks, possibly because of dilution introduced through counting all postnatal exposures. The data did not

TABLE 19.—Relative risks of leukemia associated with combinations of postnatal, intrauterine, and preconception radiation of cases and controls, adjusted for age of mother, year of birth, and pregnancy order

Type of experience	Cases	Controls	Relative risk	Probability
No radiation versus:				
1) Intrauterine and maternal preconception radiation	129	345	1. 89	0. 006
2) Intrauterine and maternal and/or paternal preconception radiation	137	359	1. 94	0. 003
3) Postnatal and parental radiation (preconception and/or intrauterine)	122	404	1. 21	0. 45
4) Any radiation, preconception and/or intrauterine and/or postnatal	306	826	1. 28	0. 05

TABLE 20.—Leukemia risk associated with intrauterine and preconception radiation of mothers of cases and controls; by pregnancy order and miscarriage or stillbirth, adjusted for age of mother

Pregnancy experience	Cases	Controls	Relative risk	Probability
1) Issue of first pregnancy	85	219	1. 85	0. 09
2) Issue of second or later pregnancy				
(*a*) Without prior miscarriage or stillbirth	104	260	2. 6	<0. 001
(*b*) With prior miscarriage or stillbirth	88	241	2. 9	0. 002

permit a more restricted presentation for children who had postnatal radiation to 2 or more sites, in addition to parental exposure.

It will be recalled that in table 7 the risk for preconception radiation considered alone was enhanced in products of second or later pregnancies, regardless of whether there had been a history of a prior fetal death. Table 14 showed a slight indication of an elevated risk among children whose mothers had previously experienced a miscarriage or stillbirth. Table 20 reports the schedule of risks associated with combined exposures to preconception and intrauterine radiation. Considering first pregnancies only, the risk of children who had received intrauterine radiation and whose mothers had also had preconception radiation was 1.9 times that of subjects who had not had such a combination of exposures. Mothers with second or later pregnancies without prior history of miscarriage or stillbirth had a relative risk for preconception and intrauterine irradiation of 2.6 and those with second or later pregnancies with prior history of miscarriage or stillbirth had a corresponding risk of 2.9. All these risks are higher than those reported for preconception or intrauterine radiation considered separately.

A review of other combinations of radiation experience—postnatal and maternal preconception, etc.—was attempted with inconclusive results because of the small number of relevant observations. The one interesting difference emerging was for children whose mothers had been irradiated during their pregnancy and whose 2 parents had experienced preconception exposure; here the relative leukemia risk was 2.2.

DISCUSSION

Heretofore, the major study investigating effects of preconception diagnostic X irradiation of parents was that of Stewart, Webb, and Hewitt (*1*). In 1958, they found a relative risk for *all childhood tumors* of approximately 1.73 associated with abdominal radiation and 1.30 for radiation directed to any site administered prior to marriage of the subject's mothers. Paradoxically, their risks were considerably smaller for radiation in the period from marriage to conception. It should be emphasized that in Stewart's study (*1*) childhood cancers other than

leukemia represented approximately one half of the cases; one cannot exclude the possibility, therefore, that childhood cancers other than leukemia accounted for part of the excess risk associated with premarital X radiation in her series. Any well-founded comparison of our data with those of Stewart *et al.* would require a separate analysis of their findings for leukemia.

In our series, preconception irradiation of mothers was estimated to carry a relative risk of 1.73 for leukemia only, adjusted for age of mother, history of miscarriage or stillbirths, and pregnancy order. A high risk persisted when abdominal radiation alone was reviewed. The excess risk was concentrated among offspring of second and later pregnancies and was not prominent among the firstborn. Furthermore, although no consistent dose-response gradient could be demonstrated, exposure to large numbers of films (16+) carried a larger relative risk than exposure to smaller numbers (1–5). A risk of 1.31 was associated with irradiation of fathers prior to conception, but it was of borderline statistical significance.

Manipulations of data from tables 4 and 5 in MacMahon's (*4*) 1962 paper suggest that the relative risk of leukemia only for children who were irradiated *in utero*, adjusted by birth order and other factors, was 1.39. From tables 2 and 10 in Stewart's (*1*) 1958 paper, we derived a relative risk of leukemia only for fetal irradiation of 1.89. Ford, Paterson, and Treuting (*5*), studying leukemia in children in Louisiana, found abdominal and pelvic X-ray exposure, *in utero*, in 26.9 percent of 78 leukemia cases and 18.3 percent of 306 controls—percentages not unlike those for all sites in the present study. Polhemus and Koch (*3*) reported results similar to ours; table 21 summarizes the effects associated with intrauterine irradiation estimated by the several studies.

Our investigation of the history of intrauterine diagnostic radiation to *any site* showed that about 29 percent of cases had such experience as compared to approximately 23 percent of the controls, adjusted for year of birth, age of mother at birth, and pregnancy order; the adjusted relative risk was 1.59. In the present study we have noted the enhanced risk to radiation among mothers who had had miscarriages or stillbirths, a risk 2.2 times that for mothers without these two factors. There is no need to indicate the biological plausibility of the leukemogenic effect of intrauterine irradiation. The increase in the risk in mothers who had prior

Table 21.—Relative risk of leukemia associated with intrauterine radiation, five studies

Investigations	Risk
Ford, Paterson, and Treuting: abdominal X ray (*5*)	1. 64
Polhemus and Koch: abdominal X ray (*3*)	1. 27
Stewart, Webb, and Hewitt: abdominal X ray (*1*)	1. 89
MacMahon: abdominal X ray (*4*)	1. 39
Present study:	
X ray to all sites	1. 59
Abdominal X ray	1. 40

fetal death could also be considered plausible since prior fetal death may have resulted from a lethal mutation from exposure to one or more mutagens, including radiation; such mutagens could also be leukemogenic. The observation of an increased risk associated with preconception irradiation is of interest in view of the finding of chromosomal abnormalities in leukemia (*18–20*). Thus, it is possible that preconception radiation produces chromosomal damage in the unfertilized ovum which is related to the subsequent development of leukemia. But it should be emphasized that, at the present state of knowledge, all this must be considered very speculative and requires further study.

Our series covers a more recent span of years than those of previous investigators. Furthermore, our data relate to all diagnostic irradiation, whereas those of the other investigators (table 21) are limited to the abdominal route. This approach was dictated by the fact that only a few mothers in our series had received abdominal radiation during their pregnancies, 27 cases and 54 controls, which may reflect a decrease in the use of abdominal X rays during pregnancy in more recent years. It is interesting that, despite this, our results are similar to those of previous research.

With respect to estimation, Stewart *et al.* (*1*) found that 7.2 percent of their controls had had intrauterine radiation and MacMahon (*4*) found 10.6 percent, compared to our 6.3 percent. MacMahon's controls were patients from large, urban, often university-centered hospitals, and Stewart's from a population of persons whom local physicians could interview. Ours were from a probability sample of a large geographic area, rural and urban, including patients from many small hospitals. Because of these large differences in sampling procedures, there was no reason to expect concordant estimates among the three studies; still, the results were not too dissimilar. Our relative risk of leukemia for children whose mothers had had abdominal radiation was 1.40, which was almost identical with that of MacMahon (1.39) and in the same direction as that of Stewart *et al.* (1.89).

A number of epidemiologic studies have related postnatal radiation exposure to higher risk of leukemia. The leukemogenic effects of radiation exposure associated with the atomic explosions in Japan are well documented (*21*). Simpson and Hempelmann (*2*) have studied the effects of therapeutic radiation, particularly to the thymic region, and have found significant excesses in the number of leukemia deaths in populations so exposed. Polhemus and Koch (*3*) found an excess of diagnostic radiation in cases; they also found that about 6 times as many of their 251 leukemia patients had had deep thymic radiation as their matched controls. Small excess risks of leukemia among children receiving postnatal radiation have also been noted by Stewart (*1*) and still smaller ones by Ager *et al.* (*7*). In the present study, approximately one third of both cases and controls had experienced some form of postnatal diagnostic irradiation; there was no significant difference between them. Significantly high relative risks

were revealed, however, for diagnostic radiation directed to more than one site.

That some earlier studies of postnatal diagnostic radiation showed little excess risk of leukemia does not necessarily contradict the present findings, since our study also did not show interesting differences for diagnostic radiation *in toto*. In prior work any diagnostic exposure was considered; analysis of their data for risks associated with exposure to multiple sites might yield positive findings similar to ours.

In the previous literature, risks associated with combined exposures to radiation were not considered. In the present study, we found that exposure to intrauterine and preconception radiation in combination carried a leukemia risk of about 1.85 for first pregnancies and from 2.6 to 2.9 for second or later pregnancies.

Experimental laboratory data suggest that irradiation can be leukemogenic to animals and that it can produce chromosome aberration (*18–20, 22–25*). These findings and the observations in hand are consistent with the hypothesis that radiation may be involved in the etiology of some leukemias. Most of the findings in this study have been in terms of relative risks in the range from 1.5 to 2.0, and occasionally higher. Thus, there could be an observed association between radiation and leukemia without a causal connection. In view of the results of other epidemiological studies and experimental work, however, this explanation does not appear likely. Although a direct association between radiation and leukemia seems a more tenable hypothesis, it is possible that the relationships observed in this study are both causal and indirect.

SUMMARY

Three hundred and nineteen children with leukemia from upstate New York and the metropolitan and rural areas around Baltimore and Minneapolis-St. Paul were compared with controls drawn from a random sample of children from these areas. History of radiation exposures was verified from records of hospitals and physicians.

There were no striking differences between cases and controls on socioeconomic status, ethnic background, religion, or father's education. Differences were found in age of subject, the case series being younger than the controls.

Children of mothers who had previously experienced miscarriage or stillbirth had higher leukemia risks. Children whose mothers had experienced radiation prior to their conception had a relative risk 1.6 times that of other children, and preconception radiation of fathers carried a small excess risk, 1.31, of borderline significance. Children whose mothers were irradiated for diagnostic purposes while they were *in utero* had a risk about 1.5 times that of children not so irradiated. The risk with radiation was 2.2 for children whose mothers had had a miscarriage. Radiation exposure in the last two trimesters carried the higher risk.

Postnatal radiation exposure to more than one site carried about a twofold risk. Children with mothers exposed to preconception and *in utero* radiation had a risk about twice that of children whose mothers had not been so exposed.

Our results for intrauterine radiation are consistent with previous studies. Our finding regarding postnatal radiation considered *in toto* was similar to that of some other studies which showed no excess risk. However, we noted an excess risk associated with radiation to more than one site, which was consistent with the data of Simpson and Hempelmann and Polhemus and colleagues.

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Appendix table A.—Method of diagnosis of leukemia cases; upstate New York and Baltimore and Minneapolis-St. Paul metropolitan areas, 1959–62

Method of diagnosis	Number	Percent	Age at diagnosis (years) 0–1	2–3	4–5	6–7	8–9	10–14
Bone marrow with or without other methods	269	84.3	46	81	59	26	17	40
Blood smear alone	11	3.4	1	3	3	1	—	3
Autopsy alone	1	0.3	1	—	—	—	—	—
Blood smear and autopsy	2	0.6	—	—	—	1	—	1
Blood smear and other methods, except bone marrow or autopsy	19	6.0	1	6	3	3	1	5
Clinical picture or X ray	5	1.6	4	1	—	—	—	—
No information available	12	3.8	1	3	2	1	—	5
Total	319	100.0						

Appendix table B.—Histologic type of leukemia cases; upstate New York and Baltimore and Minneapolis-St. Paul metropolitan areas, 1959–62

Type of leukemia	Number	Percent
Acute lymphatic	201	63.0
Acute myeloid	36	11.3
Acute monocytic	11	3.4
Acute stem cell	15	4.7
Acute granulocytic	2	0.7
Acute unspecified	23	7.2
Subacute lymphatic	8	2.5
Chronic myeloid	7	2.2
Chronic monocytic	3	0.9
Chronic stem cell	6	1.9
Chronic unspecified	1	0.4
Leukemia unspecified	6	1.9
Total	319	100.0

[illegible]

Morbidity Survey and Case Register Estimates of Cancer Incidence [1]

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DORN is perhaps best known for his work in the epidemiology of cancer. He directed the study that provided the first satisfactory body of data on morbidity from cancer in the United States (*1*). The survey methodology developed in collaboration with Mountin in the late 1930's (*2*) was utilized again in the late 1940's to provide the data for *Morbidity from Cancer in the United States*, still the most comprehensive work to date on morbidity from cancer in the United States (*3*).

Estimates of cancer incidence derived from morbidity surveys have been thought by some to overestimate true incidence, especially since they were somewhat at variance with those from cancer case registers in Connecticut and up-State New York. The conflicting evidence on the incidence of cancer as derived from register and morbidity survey sources has been summarized by Levin *et al.*, who noted that incidence rates based on morbidity survey data in Iowa markedly exceeded rates from cancer registers in Connecticut and New York for cancers of the lip, skin, prostate, breast, cervix, and corpus uteri (*4*). Incidence rates for Iowa resembled those for some of the cities included in the 10-city surveys (*3*). The Iowa and 10-city surveys had been carried out in a similar manner by use of the aforementioned morbidity survey methodology.

The apparent discrepancies between estimates of cancer incidence derived from case register and survey sources were discussed informally by Dorn and his colleagues on numerous occasions. He was not convinced that the rates from survey data were necessarily overstated and thought that the matter required further study (*5*). Levin *et al.* suggested that the interpretation and reconciliation of incidence rates from register and survey sources were a complex problem requiring further investigation. The recommended approach to the problem was to conduct independently

[1] This paper reports on the findings of a cooperative study between the Department of Biostatistics, Graduate School of Public Health, University of Pittsburgh, and the National Cancer Institute.

[2] I wish to acknowledge the assistance of Mr. Arthur LeGasse who participated in processing the data for this study.

[3] National Institutes of Health, Public Health Service, U.S. Department of Health, Education, and Welfare.

a morbidity survey in an area with a cancer register and to reconcile the findings (*4*).

Conflicting evidence on incidence such as that described for Iowa and Connecticut could arise because of some fundamental differences in the populations at risk in different areas. On the other hand, differences in computed incidence rates may reflect systematic biases associated with specific techniques for data collection. For example, case registers may be incomplete because of underreporting. This is especially likely for sites in patients not requiring hospitalization and when private physicians are not asked to report on cases coming to their attention. Or, discrepancies may arise from failure to exclude previously diagnosed cases in survey returns. If this were so, one may expect survey returns to display a more unfavorable stage distribution and survival because the survey would count some previously diagnosed patients who had returned to treatment during the time covered by the survey. Presumably, these individuals would now present an advanced stage of the disease and would survive for a shorter time. If there were substantial numbers of these individuals, the survey results would then include a disproportionate number of persons with metastases and consequently lower survival rates. Up to now, the inability to uncover such effects (*6*), plus the fact that differences in incidence appear for a limited number of sites, tends to favor underreporting to cancer registers as a more likely explanation. Lapses in transmission of diagnostic information can occur within hospitals and could affect the data for some sites more than for others. The study reported on here was designed to provide a direct check of the two alternatives. A morbidity survey for 1957–58 was carried out in Allegheny County, Pennsylvania, an area with an ongoing cancer register. Morbidity survey and case register estimates of cancer incidence may be examined, and the contribution of each of the methodologies to discrepancies in estimates of cancer incidence may be compared directly.

RESULTS

A cancer case register has been maintained in Allegheny County since 1955. Abstracts of records of cancer patients are submitted to the register from hospital record rooms or tumor clinics, as well as from supplementary sources, *e.g.*, nursing homes and the American Cancer Society. In addition, mortality records of the State Office of Vital Statistics are searched and cases are recorded for whom medical certification of cancer as a cause of death was the only source of information on the first diagnosis of cancer. Generally, neither private physicians nor intrahospital departments other than record rooms or tumor clinics submit abstracts of records directly to the register. During 1960, an independent morbidity survey covering cancer cases diagnosed in 1957 and 1958 was carried out in Allegheny County by the National Cancer Institute in cooperation with the Graduate School of Public Health of the University of Pittsburgh.

The survey methodology was similar to that utilized for the Iowa and 10-cities studies. All sources of medical records not routinely reporting to the Allegheny County Registry were canvassed. These included all the private physicians in the county and departments, such as Pathology, Radiology, Obstetric, and Out-Patient, within hospitals in the reporting system. Normal registry sources within the hospitals, *i.e.*, central records and tumor clinics, were sampled to insure completeness of coverage. During the years covered by the morbidity survey, the Allegheny County Cancer Registry was receiving abstracts of records of cancer patients from all the hospitals located in the county.

The procedures used allowed the desired twofold view of the situation. Probably nearly all cases of cancer first diagnosed among residents of Allegheny County in 1957 or 1958 were enumerated by one method or the other. From past register records, it is possible to determine the number of cases that would have been erroneously counted as new cases in the morbidity survey because of lack of information on records for a single year. Conversely, the extent of underreporting to the register can be determined by examination of the records systems normally outside the central registration routine. Survey and register estimates may then be compared with each other as well as with the best estimate of cancer incidence based on all sources of data.

There were 10,460 residents of Allegheny County for which the first diagnosis on the basis of all available information was recorded in 1957 or 1958. Table 1 gives the number of cases recorded in the register and the number outside the registration system by primary site. Records of 81.9 percent of all cancer cases first diagnosed in 1957–58 were available through the central registration system. The remainder were identified through record systems normally outside the flow of records to the central register. When skin cancers are excluded, the proportion of cases available to the central registry is increased to 86.1 percent. The registry, however, would have underestimated the true incidence for nearly every primary site during these years, although the extent of this underestimation is more serious for some sites than for others. The percentage by which the register underestimated true incidence ranged from less than 10 percent for ovary, esophagus, and stomach to 54 percent for skin.

On the other hand, the morbidity survey alone would have included some old or previously diagnosed cases as newly diagnosed in 1957–58 without means to identify them as old cases. Table 2 summarizes, by primary site, the count of cases that would have resulted from the morbidity survey alone and the count that would have resulted if the registry were the only source of information. Clearly, the morbidity survey would have provided some overestimate of the true incidence. But the level of overestimation is relatively small, only 2.1 percent for all sites, excluding skin, compared with the 13.9 percent underestimate on the part of the register. Overestimation of true incidence by the survey was highest for bladder (4.6%), bone (4.3%), and lymphomas (3.9%) and

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TABLE 1.—Number of cancer cases first diagnosed among residents of Allegheny County, Pennsylvania, in 1957–58, by registry status and primary site

Primary site	International List Nos. (7th revision)	All cases	Recorded in register			Not recorded in register
			Total	Reported cases	Death certificate only	
All sites	140–205	10, 460	8, 568	7, 516	1, 052	1, 892
All sites excluding skin		9, 368	8, 066	7, 024	1, 042	1, 302
Buccal cavity and pharynx	140–148	342	289	264	25	53
Lip	140	40	26	26	0	14
Digestive system	150–159	2, 802	2, 494	2, 081	413	308
Esophagus	150	157	144	116	28	13
Stomach	151	568	514	394	120	54
Large intestine	153	984	878	741	137	106
Rectum	154	551	492	452	40	59
Respiratory system	160–164	978	853	817	36	125
Larynx	161	149	126	121	5	23
Lung and bronchus	162	799	701	671	30	98
Breast	170	1, 182	1, 021	939	82	161
Female genital organs	171–176	1, 032	913	839	74	119

Cervix uteri	171	361	314	291	23	47
Corpus and other uterus	172–174	392	343	314	29	49
Ovary	175	199	184	165	19	15
Male genital organs	177–179	618	505	430	75	113
Prostate	177	544	446	374	72	98
Urinary organs	180–181	573	482	446	36	91
Kidney	180	133	109	95	14	24
Bladder	181. 0	437	370	348	22	67
Skin	190–191	1, 092	502	492	10	590
Brain and nervous system	193	167	128	109	19	39
Endocrine glands	194–195	101	74	69	5	27
Bone	196	44	33	28	5	11
Soft tissues	197	74	51	50	1	23
Leukemias	204	265	205	175	30	60
Lymphomas	200–203; 205	391	306	280	26	85
Other and unspecified	192, 199	799	712	497	215	87

TABLE 2.—Comparison of case register and morbidity survey estimates of cancer incidence among residents of Allegheny County, Pennsylvania, in 1957–58, by primary site

Primary site	International List Nos. (7th revision)	Best estimate of incidence 1957–58	Survey estimate of incidence	Percent over estimate by survey	Register estimate of incidence	Percent under estimate by register	Ratio: survey-to-register estimate
All sites	140–205	10, 460	10, 694	2. 2	8, 568	18. 1	1. 25
All sites excluding skin		9, 368	9, 561	2. 1	8, 066	13. 9	1. 18
Buccal cavity and pharynx	140–148	342	349	2. 0	289	15. 5	1. 21
Lip	140	40	41	2. 5	26	35. 0	1. 58
Digestive system	150–159	2, 802	2, 845	1. 5	2, 494	11. 0	1. 14
Esophagus	150	157	160	1. 9	144	8. 3	1. 11
Stomach	151	568	574	1. 1	514	9. 5	1. 12
Large intestine	153	984	997	1. 3	878	10. 8	1. 14
Rectum	154	551	570	3. 4	492	10. 7	1. 16
Respiratory system	160–164	978	996	1. 8	853	12. 8	1. 17
Larynx	161	149	152	2. 0	126	15. 4	1. 21
Lung and bronchus	162	799	810	1. 4	701	12. 3	1. 16
Breast	170	1, 182	1, 225	3. 5	1, 021	13. 6	1. 20
Female genital organs	171–176	1, 032	1, 049	1. 6	913	11. 5	1. 15
Cervix uteri	171	361	370	2. 5	314	13. 0	1. 18
Corpus and other uterus	172–174	392	395	0. 8	343	12. 5	1. 15
Ovary	175	199	203	2. 0	184	7. 5	1. 10

Male genital organs	177–179	618	633	2. 4	505	18. 3	1. 25
Prostate	177	544	558	2. 6	446	18. 0	1. 25
Urinary organs	180–181	573	595	3. 7	482	15. 9	1. 23
Kidney	180	133	135	1. 5	109	18. 0	1. 24
Bladder	181. 0	437	457	4. 6	370	15. 3	1. 24
Skin	190–191	1, 092	1, 133	3. 6	502	54. 0	2. 26
Brain and nervous system	193	167	168	0. 6	128	23. 4	1. 31
Endocrine glands	194–195	101	103	1. 9	74	26. 7	1. 39
Bone	196	44	46	4. 3	33	25. 0	1. 39
Soft tissues	197	74	75	1. 3	51	31. 1	1. 47
Leukemia	204	265	268	1. 1	205	22. 6	1. 31
Lymphoma	200–203; 205	391	407	3. 9	306	21. 7	1. 33
Other and unspecified	192, 199	799	802	0. 4	712	10. 9	1. 13

lowest for corpus and other uterus (0.8%), brain and nervous system (0.6%), and other and unspecified sites (0.4%).

Some idea of the divergence between estimates of incidence by the two methodologies for this series may be obtained from the last column of table 2, which gives the ratios of survey-to-registry estimates of incidence by site. More than two thirds of these ratios are greater than 1.15, the highest being 2.26 for skin cancer. Since each estimate covers the same time, place, population, etc., divergent estimates are due only to differences in techniques of data collection. And, if the registry data were complete, there would be little, if any, difference between the two series.

Because underenumeration by the registry weighs most heavily in the divergent estimates, table 3 examines the sources of the 1,892 case records not available to the registry. Fifty-four percent of these case records were found in records of pathology departments of local hospitals and an additional 31 percent were available only through private physicians. Neither of these sources reports directly to the Allegheny County Registry, so that underenumeration does not result from lapses in transmission of information from a regular reporting source to the Allegheny County Registry but from record sources outside the direct flow to the registry.

The major part of 1,892 case records was found in records of pathology departments, all within reporting hospitals. None of these records appeared in the central record systems of the hospitals involved, which indicates that it is unlikely that any of these were in-patients. Private physicians accounted for 31 percent of the 1,892 records and among these surgeons and dermatologists contributed the greatest numbers. In fact, if only pathology departments of local hospitals and physicians specializing in dermatology or surgery had been incorporated into the registration system, the incidence estimates based on register records would be only 6 percent below the best estimate that could be made from all sources of data. This indicates that substantially complete registration of cancer patients could be achieved in the Allegheny County Registry if selected intrahospital record sources and physicians in one or two specialties were added to the registration system.

DISCUSSION

The extent to which the results for Allegheny County may apply to other registration systems is not known. Estimates of cancer incidence obtained from the morbidity survey data are substantially different from those of the cancer register. Levin *et al.* noted that the Iowa morbidity survey rates markedly exceeded those of the Connecticut register for lip, breast, cervix, corpus, prostate, and skin. Iowa-to-Connecticut ratios of urban incidence rates along with the survey-to-register ratios for Allegheny County are shown.

Primary site	Iowa/Connecticut: Ratios of urban incidence rates, Male	Iowa/Connecticut: Ratios of urban incidence rates, Female	Survey/Register: Ratios of incidence estimates in Allegheny County
All sites	1. 29	1. 35	1. 25
Lip	3. 20	6. 00	1. 58
Breast		1. 30	1. 20
Uterus (total)		1. 58	1. 16
Cervix		2. 12	1. 18
Corpus		1. 77	1. 15
Prostate	1. 36		1. 25
Skin	2. 33	2. 06	2. 26

The survey-to-register ratios for Allegheny County are of the same order of magnitude as the Iowa-to-Connecticut ratios for breast, prostate, and skin. This suggests that the Iowa-Connecticut differences in incidence for these sites may reflect differences in completeness of reporting rather than true interarea differences in incidence. On the other hand, substantial differences in incidence between Iowa and Connecticut for lip, cervix, and corpus would remain even after adjustment for possible differences in reporting for the two areas. Conceivably, therefore, the Iowa-Connecticut differences for these sites reflect real interarea differences in incidence and not merely differences in reporting. In Iowa, cases of unspecified uterus were distributed between cervix and corpus. Although this allocation could account for some of the remaining differences for these sites between Iowa and Connecticut, it would not affect the difference between the two series for total uterus.

Clearly, in Allegheny County, estimates of cancer incidence derived from the morbidity survey would be quite different from those of the register. The difference primarily is due to underreporting to the cancer register, which results in part from the failure to utilize all intrahospital record sources. If the records of hospital pathology departments and selected private physicians were added to the registration system, coverage in Allegheny County would be nearly complete. In view of this, it would seem appropriate to suggest that other central registration systems examine the flow of incoming records to determine whether information available from intrahospital record systems is being transmitted to the central register. It may not be economically feasible to attempt registration of all cancer patients in an area with a central register by canvassing each private physician. However, the inclusion of intrahospital data sources would be relatively easy to undertake and could result in a substantial step toward complete coverage.

SUMMARY

A primary objective of this study was to provide a comparison of the estimates of cancer incidence derived from morbidity surveys with those

TABLE 3.—Source of report for cases of cancer first diagnosed among residents of Allegheny County, Pennsylvania, but not recorded in central register, by primary site

Primary site	International List Nos. (7th revision)	All sources	Source of report				
			Hospital				
			Total	Pathology departments	Other	Physicians	All other
All sites	140–205	1,892	1,272	1,028	244	588	32
All sites excluding skin		1,302	875	670	205	401	26
Buccal cavity and pharynx	140–148	53	45	40	5	7	1
Lip	140	14	12	12	0	2	0
Digestive system	150–159	308	189	144	45	116	3
Esophagus	150	13	4	4	0	9	0
Stomach	151	54	26	19	7	27	1
Large intestine	153	106	72	57	15	34	0
Rectum	154	59	38	26	12	20	1
Other		76	49	38	11	26	1
Respiratory system	160–164	125	75	57	18	47	3
Larynx	161	23	20	17	3	3	0
Lung and bronchus	162	98	51	37	14	44	3
Other		4	4	3	1	0	0

Breast	170	161	109	83	26	49	3
Female genital organs	171–176	119	79	60	19	36	4
Cervix	171	47	25	18	7	18	4
Corpus and other uterus	172–174	49	39	32	7	10	0
Ovary	175	15	10	6	4	5	0
Other		8	5	4	1	3	0
Male genital organs	177–179	113	79	66	13	31	3
Prostate	177	98	71	62	9	24	3
Other		15	8	4	4	7	0
Urinary organs	180–181	91	76	55	21	14	1
Kidney	180	24	20	18	2	4	0
Bladder	181. 0	67	56	37	19	10	1
Skin	190–191	590	397	358	39	187	6
Brain and nervous system	193	39	29	23	6	10	0
Endocrine glands	194–195	27	21	16	5	5	1
Bone	196	11	7	4	3	4	0
Soft tissue	197	23	18	13	5	5	0
Leukemias	204	60	31	19	12	26	3
Lymphomas	200–203; 205	85	56	41	15	27	2
Other and unspecified	192, 199	87	61	49	12	24	2

from a continuing cancer case register. A direct comparison of register and survey data in Allegheny County, Pennsylvania (an area with an ongoing register), was made possible when an independent morbidity survey, utilizing study techniques developed largely by Dorn, was carried out. The two techniques yielded substantially different estimates of cancer incidence for a number of sites. In each case, differences were primarily due to underenumeration by the register. Although the survey did count some old, previously diagnosed cases as new cases, this methodology provided estimates of incidence that were considerably closer to the best estimates of incidence, on the basis of all information, than did the register.

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Morphology and Survival Rates of Cervical Cancer in Connecticut and Southwest England

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Different population groups show wide variations in incidence, mortality, and survival rates of cervical cancer, but reasons for these variations are not completely understood. Large-scale cancer registry systems offer many opportunities to explore factors associated with the occurrence of cervical cancer and with their effects on survival.

The work described here was designed as a pilot study in international collaborative research between cancer registries, with the specific objective of studying reported differences in cervical cancer incidence and survival between Connecticut and the Southwestern Hospital Board Region (SWR) of England. Cancer of the uterine corpus was included as a control. The detailed review of cervical cancer was undertaken with the thought that it might lead to a reconciliation of the tumor registry data for the two areas, and that either positive or negative findings could set the stage for future epidemiologic studies.

In both regions, the registries collect certain basic data on all known cancer patients, including those not admitted to hospitals and found only by search of death certificates. Reporting of cancer is believed to be essentially complete.

In 1959, when this study was initiated, the available cervical cancer incidence rates per 100,000 women (age-adjusted) were 20.2 in Connecticut (for 1947–51) and 14.6 in the SWR (for 1954–57). This difference, combined with a higher 5-year survival rate in Connecticut (50% compared

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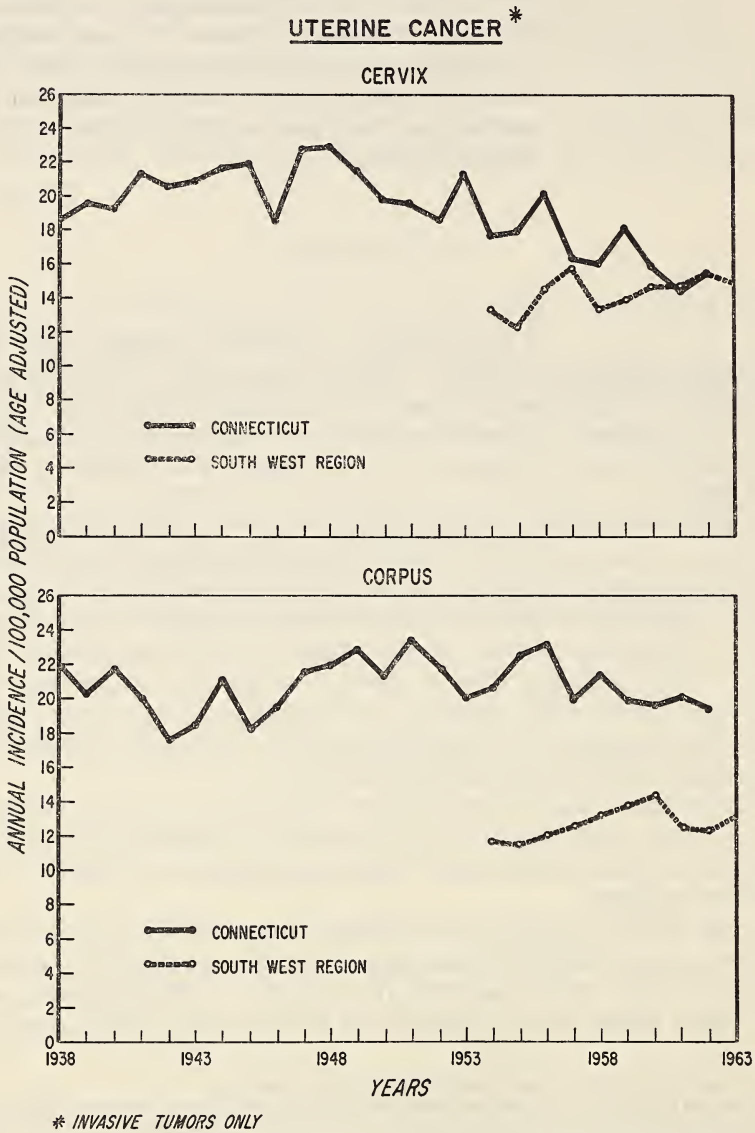
[6] We wish to thank the pathologists of Connecticut and the Southwestern Hospital Board Region of England for the time they spent working with us and for providing the pathologic specimens. We also thank Mrs. Aviva Kesselman for her help in many aspects of data processing, and Mrs. A. D. Thomson and Mrs. Helen Scott for help in abstracting records. We are indebted to Mrs. E. M. Longstaffe and Major L. Leyland for assisting the field work in many ways.

[7] National Institutes of Health, Public Health Service, U.S. Department of Health, Education, and Welfare.

with 34%), led us to undertake the work described. However, the incidence of invasive cervical cancer in Connecticut had declined in the interim, so that the incidence rates were closer in the 2-year period studied (1957–58) (text-fig. 1).



TEXT-FIGURE 1.—Trends in age-adjusted incidence rates for cancer of the uterine cervix and corpus, Connecticut, 1938–62, and the Southwestern Hospital Board Region of England, 1954–63.

Although text-figure 1 reports data on cervical cancer incidence in Connecticut for the 25-year span 1938–63, the collection of data by the

Registry began in 1935. The SWR Registry was started about 1945 but did not attempt to collect complete case record data (including records for patients reported only by death certificates) until 1954, so age-adjusted rates for earlier years are not available. Because of differences in the method of age adjustment and in the inclusion or exclusion of cases with carcinoma *in situ*, these rates are not fully consistent with those published elsewhere by the two Registries.

The previously observed difference in survival of cervical cancer patients has persisted. A difference in the incidence of corpus cancer, not associated with a difference in survival, has also remained relatively stable. Table 1 shows incidence rates and 5-year survival rates for both cervical and corpus cancer for cases occurring during 1957–58. Detailed study of survival in Connecticut and in the whole of England and Wales, not just the SWR, has shown the latter to have lower survival rates in every age and stage category (*1*).

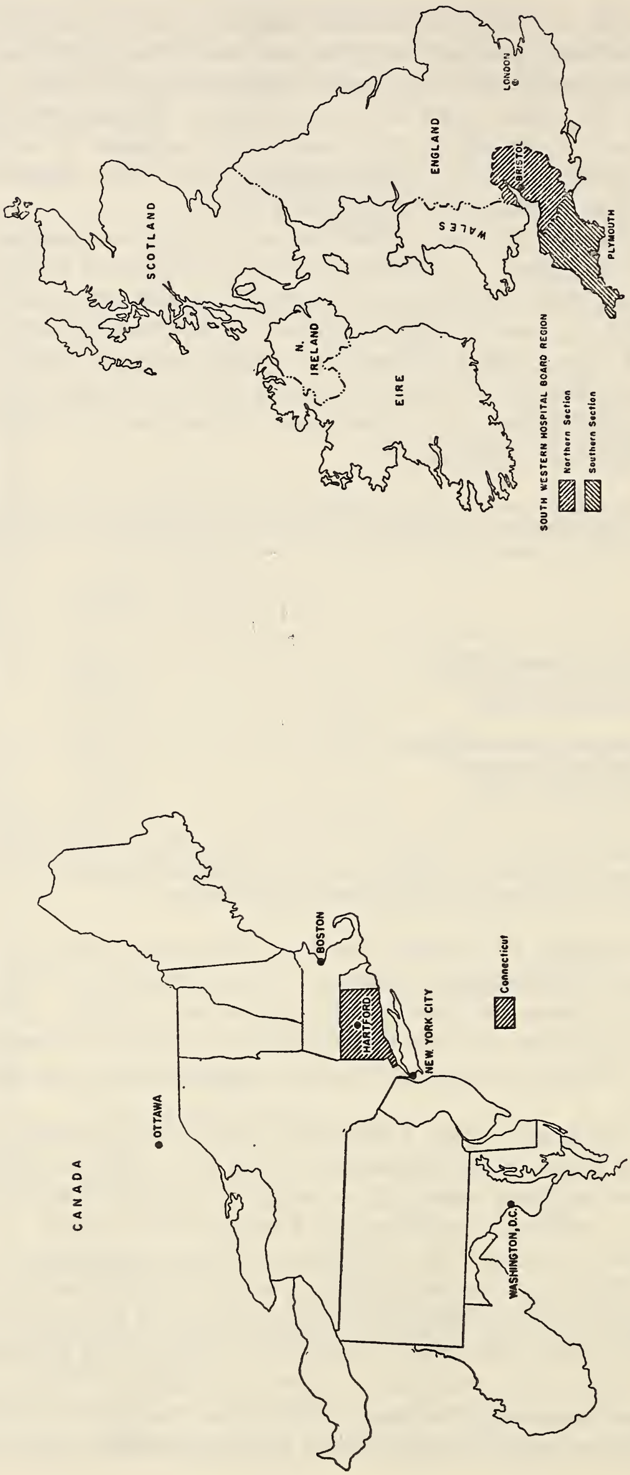
TABLE 1.—Number of cases of uterine cancer, annual incidence rate, and 5-year survival rate,* by site, Connecticut and the Southwest Region of England

	Connecticut	Southwest Region, England
Cervix: Number of cases 1957–58	401	471
Annual incidence rate†	16. 0	12. 9
5-year survival rate	0. 48	0. 35
Corpus: Number of cases 1957–58	533	575
Annual incidence rate†	20. 6	13. 3
5-year survival rate	0. 61	0. 55
Cervix-corpus ratio	75%	82%

*All survival rates in this and the following tables were calculated by the life-table method.
†Rate per 100,000 women, indirect age-adjusted to the U.S. 1950 population.

The cervix-corpus ratio is less than 1.0 in both areas (table 1). Careful examination of registration practices, as well as hospital and other records, confirms that these low cervix-corpus ratios are genuine. The stable rate for corpus cancer and the declining rate for cervical cancer shown in text-figure 1 imply that the cervix-corpus ratio has also been declining in recent years.

In 1959, the late Dr. Alan McKenzie of the General Registry Office of England and Wales visited Connecticut to study the differences in reported incidence and survival rates. As a result of his visit, it was decided to undertake a combined pathologic and epidemiologic study of cervical cancer in the two areas. It was agreed that two pathologists, one from the United States and one from England, would together visit all hospitals in each area and jointly review histologic sections of all cases of invasive cancer of the uterine cervix and corpus first diagnosed in Connecticut or the SWR during 1957 and 1958. Cases of carcinoma *in situ* also were reviewed and separately analyzed. Their work was to be supplemented by an analysis of epidemiologic data in the corresponding cancer registers



TEXT-FIGURE 2.—Cancer registration areas, Connecticut and Southwestern Hospital Board Region of England.

to determine reasons for any observed differences in incidence or survival rates. Text-figure 2 shows the areas covered by the survey. The two regions are approximately the same size and are similar in many other characteristics, such as population density, climate, and geography. The English region is divided into a northern and southern section for administrative purposes.

The first step in the study was a re-examination of microscopic slides for all cases of cervical and corpus cancer to verify the original diagnosis. For invasive squamous cell carcinoma of the cervix, detailed information about the microscopic appearance of the tumor was also collected. A more detailed description of the study methods and of the case material has been given elsewhere (*2*).

There were 1,980 cases[8] having the 4 criteria for study: 1) The tumor must be primary in the uterine cervix or corpus; 2) invasive; 3) first diagnosed in 1957 or 1958; and 4) the patient a resident of the study area at the time of diagnosis (table 1). There were also reviewed 278 tumors reported as carcinomas *in situ.*

Among the 1,980 invasive cancer cases there were 872 with cancer of the cervix (table 2). A more detailed classification of these tumors, and of the 48 tumors reported to the registries but deleted after review of records and microscopic slides, has also been presented elsewhere (*2*). For tumors that could be reviewed microscopically, it was found that nearly every lesion reported as invasive cancer in Connecticut would also be considered invasive in the Southwest Region of England, and vice versa. Therefore, apparently the reported difference in survival rates is *not* the result of different criteria for the microscopic diagnosis of invasive cancer, or the result of including carcinoma *in situ* or nonmalignant lesions with invasive tumors in Connecticut.

TABLE 2.—Distribution of invasive cervical cancers

	Connecticut		Southwest Region, England		Total	
All cervical cancers	401		471		872	
Squamous cell tumors	324		381		705	
Reviewed in detail		277		358		635
Confirmation of cell type only		47		23		70
Other histologic types	14		17		31	
Not reviewed microscopically	63		73		136	
Slides not available		45		9		54
No biopsy		1		24		25
Reported only by death certificate		17		40		57

These observations on cervical cancer incidence and survival rates provide the basis for a combined analysis of both incidence and survival

[8] Two patients found to be nonresidents were deleted from the 1,982 patients reported earlier (*2*).

in relation to certain histologic features of the cervical cancers. This is the first such study based on all known cases in a defined population.

HISTOLOGIC FEATURES OF CERVICAL CANCER

Table 3 shows the ten histologic features examined for the 635 squamous cell carcinomas of the cervix that could be reviewed in detail. Comparison of the percent distributions for these ten characteristics shows a remarkable similarity between cases in Connecticut and the SWR. It is immediately apparent that there are no gross differences in the histologic appearance of invasive squamous cell carcinomas of the cervix in Connecticut and the SWR, and that the difference in survival rates must have some other explanation. A more detailed pathologic description of these various histologic features and of the relationships among them will be reported elsewhere.

OVER-ALL SURVIVAL RATES

During 1957–58 there were 401 patients in Connecticut and 471 in the SWR reported to have a new diagnosis of invasive cervical cancer: These numbers include patients not admitted to hospitals and reported only by death certificates (table 2). Five-year survival rates for these patients were 48 percent in Connecticut and 35 percent in the SWR (table 4). This is a large and highly significant difference. Five-year survival of only those patients admitted to hospitals was somewhat higher in both areas but again showed a highly significant difference, 50 percent in Connecticut and 38 percent in the SWR (table 4).

In contrast, 5-year survival rates of patients with cancer of the uterine corpus admitted to hospitals were almost identical in Connecticut and the SWR, 63 and 62 percent, respectively.

The clinical stage classification differs in Connecticut and the SWR so that the registry data for clinical stage of cervical cancer in the two areas are not exactly comparable. The SWR uses the 4-stage International System based on pretreatment information, while Connecticut uses a 3-stage system based on all information available after the first course of treatment, which may include surgical exploration and pathologic findings. Within each area there was a strong correlation between stage and survival (table 5).

Although the cancer registry data on stage cannot be used for comparisons between Connecticut and the SWR, some inferences may be made from data submitted by single hospitals to the well-known Stockholm reports (*3*). Recent treatment, stage, and survival data for hospitals in Southern England and in the Northeastern United States are summarized in table 6. The U.S. patients had higher over-all 5-year survival rates (49.5% vs. 37.2%) as well as a more favorable stage distribution; this

TABLE 3.—Distribution of morphologic features studied in detail

	Total	Connecticut		Southwest Region, England	
		Number	Percent	Number	Percent
Pattern:					
Solid	61	33	11. 9	28	7. 8
Fingers	563	236	85. 2	327	91. 3
Indeterminate	3	3	1. 1	0	0. 0
Mixed	8	5	1. 8	3	0. 8
Necrosis:					
None	462	178	64. 3	284	79. 3
Slight	150	91	32. 8	59	16. 5
Moderate	16	7	2. 5	9	2. 5
Marked	7	1	0. 4	6	1. 7
Bizarre cells:					
Inconspicuous	601	257	92. 8	344	96. 1
Conspicuous	34	20	7. 2	14	3. 9
Eosinophils:					
Inconspicuous	586	244	88. 1	342	95. 5
Conspicuous	49	33	11. 9	16	4. 5
Squamous cell (%):					
0	8	8	2. 9	0	0
25	20	16	5. 8	4	1. 1
50	36	25	9. 0	11	3. 1
75	457	190	68. 6	267	74. 6
100	114	38	13. 7	76	21. 2
Keratinous debris:					
None	394	159	57. 4	235	65. 6
Slight	165	83	30. 0	82	22. 9
Moderate	45	22	7. 9	23	6. 4
Marked	30	13	4. 7	17	4. 8
Unspecified	1			1	0. 3
Fibrosis:					
Inconspicuous	87	48	17. 3	39	10. 9
Conspicuous	548	229	82. 7	319	89. 1
Differentiation:					
Well differentiated	36	15	5. 4	21	5. 9
Average	528	229	82. 7	299	83. 5
Undifferentiated	67	29	10. 5	38	10. 6
Unspecified	4	4	1. 4	0	0
Mitoses:					
0–4 per high-power field	594	247	89. 2	347	96. 9
5+ per high-power field	41	30	10. 8	11	3. 1
Plasma cells:					
Inconspicuous	562	227	82. 0	335	93. 6
Conspicuous	73	50	18. 0	23	6. 4

suggests that tumor stage may account at least in part for the Connecticut-SWR survival differential. However, a detailed study of staging practices in the two areas would be necessary before any firm conclusion could be drawn.

Data on tumor stage and specific morphologic features are not included here because there seems to be no relationship between them. In this series, none of the morphologic features studied were found significantly more often than average in any tumor stage group.

Older patients with cervical cancer generally have lower survival rates than younger ones, even after adjustment for the higher "natural" mortality of the older patients from diseases other than cervical cancer. An earlier study of survival rates in Connecticut and in England and Wales

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TABLE 4.—Distribution of cases of uterine cancer with 5-year survival rates for Connecticut and the Southwest Region of England

	Combined series		Connecticut		Southwest Region, England	
	Number	5-year survival	Number	5-year survival	Number	5-year survival
Cervical cancer (invasive)						
All patients	872	0.41	401	0.48	471	0.35
Admitted to hospitals	815	0.44	384	0.50	431	0.38
Squamous cell carcinoma	705	0.44	324	0.49	381	0.39
Other specific cell types	31	0.32	14	0.19	17	0.41
Cell type not determined	79	0.51	46	0.65	33	0.28
Corpus cancer						
All patients	1,108	0.58	533	0.61	575	0.55
Admitted to hospitals	1,023	0.63	513	0.63	510	0.62
Adenocarcinoma	880	0.66	438	0.65	442	0.67
Other specific cell types	80	0.35	43	0.37	37	0.32
Cell type not determined	63	0.53	32	0.71	31	0.19

TABLE 5.—Five-year survival of patients with cervical cancer by tumor stage

Stage	Number of patients	5-year survival
Connecticut—all stages*		
Localized†	223	0. 63
Regional	86	0. 36
Remote	19	0. 16
Stage not determined	56	0. 28
Southwest Region—all stages*		
Stage I	107	0. 64
Stage II	122	0. 45
Stage III	117	0. 29
Stage IV	56	0. 02
Stage not determined	29	0. 17

*All patients reported in hospitals.
†Includes carcinoma *in situ.*

showed that the unfavorable experience among older women was mostly or entirely due to their higher proportion of advanced tumors (*1*). Survival rates by age for the present series are given in table 7.

SURVIVAL AND HISTOLOGIC FEATURES OF CERVICAL CANCER

Table 8 presents 5-year survival rates by tumor morphology for the combined series and for the two areas separately. Four of the histologic features ("tumor pattern," "keratinous debris," "bizarre cells," and "fibrosis") do not seem related to survival rates and will not be discussed further in this connection.

Four other features—the proportion of squamous cells to basal-type cells in the tumor, necrosis of the tumor, a plasma cell reaction around the tumor, and an eosinophilic cell reaction around the tumor—show a suggestive but not statistically significant relation to survival rates. Survival was lower than average for those patients whose tumor was composed of 100 percent squamous cells as compared to those with 25, 50, or 75 percent squamous cells. There were only 8 patients with cervical carcinomas made up of 100 percent basal-type cells (0% squamous cells) and 5 (68%) of these have survived more than 5 years (table 8). Survival was higher for those patients whose cervical carcinomas exhibited no, or only slight, necrosis as compared to those with moderate necrosis, and only 1 of 7 patients with marked necrosis survived 5 years. Survival was above average for those patients with a conspicuous infiltration of either plasma cells or eosinophils.

Patients with "five or more mitoses" per high-power microscopic field had lower survival rates than other patients (27% vs. 46%); this difference is statistically significant.

Although survival decreased from "well-differentiated" to "undifferentiated" tumors, the differences are not statistically significant.

TABLE 6.—Patients with cervical cancer treated in Southern England and in Northeastern United States*

Hospital No.	Location of hospital	Number of patients 1950–54	Percent treated only by surgery	5-year recovery rate,† all treated patients	Percent distribution of cases, by stage				5-year recovery rate, by stage‡			
					I	II	III	IV	I	II	III	IV
Southern England												
71	Bristol	210	23. 8	35. 2	20. 5	39. 0	28. 6	11. 9	72. 1	42. 7	10. 0	8. 0
73	Cardiff	307	11. 1	37. 8	16. 0	48. 5	34. 2	1. 3	65. 3	42. 3	20. 0	*0. 0*
78	London	288	1. 7	35. 1	24. 3	51. 4	18. 4	5. 9	60. 0	32. 4	20. 8	0. 0
79	London	184	32. 6	37. 0	25. 5	37. 5	20. 7	16. 3	68. 1	37. 7	15. 8	13. 3
80	London	355	20. 8	37. 5	23. 4	43. 7	19. 4	13. 5	68. 7	41. 3	15. 9	2. 1
81	London	103	12. 6	40. 8	13. 6	42. 7	35. 0	8. 7	*85. 7*	54. 5	11. 1	*22. 2*
83	Northwood	308	11. 0	37. 7	23. 4	37. 3	20. 8	18. 5	54. 2	49. 6	25. 0	7. 0
85	Southampton	281	0. 0	38. 1	16. 0	38. 8	37. 0	8. 2	68. 9	51. 4	18. 3	4. 3
Total		2, 036	13. 3	37. 2	20. 8	42. 8	26. 0	10. 5	65. 2	42. 8	17. 8	6. 6
Northeastern United States												
87	Boston	389	49. 9	49. 4	36. 8	41. 9	14. 1	7. 2	72. 7	47. 9	14. 5	7. 1
92	New Haven	131	18. 3	55. 0	44. 3	35. 1	11. 5	9. 2	74. 1	54. 3	20. 0	*8. 3*
94	New York	137	72. 3	55. 5	46. 0	32. 1	14. 9	7. 3	76. 2	59. 1	10. 0	*0. 0*
95	New York	277	37. 2	50. 5	41. 2	33. 2	18. 4	7. 2	71. 1	48. 9	27. 5	0. 0
96	New York	157	16. 6	40. 1	42. 0	42. 0	12. 7	3. 2	62. 1	27. 3	20. 0	*0. 0*
100	Providence	156	6. 4	47. 4	37. 8	34. 0	17. 3	10. 9	62. 7	50. 9	37. 0	0. 0
Total		1, 247	36. 6	49. 5	40. 3	37. 2	15. 1	7. 4	70. 4	47. 2	21. 8	3. 3

*Data from (*3*). Table includes treated patients only.
†Percent of patients known to be alive and cancer-free.
‡Rates based on fewer than 15 cases in italics.

TABLE 7.—Cervical cancer survival rates by age and stage,* Connecticut and the Southwest Region of England, 1957–58

	All ages		Under 45		Age 45–59		60 and over	
	Number	5-year survival	Number	5-year survival	Number	5-year survival	Number	5-year survival
Connecticut								
All stages	268	0. 51	79	0. 53	110	0. 51	79	0. 46
Localized	153	0. 65	50	0. 64	62	0. 68	41	0. 62
Regional extension	69	0. 38	21	0. 43	27	0. 33	21	0. 38
Remote metastases	12	0. 08	4	—	5	—	3	—
Unspecified	34	0. 60	4	—	16	—	14	—
Southwest Region								
All stages	351	0. 41	85	0. 48	140	0. 41	126	0. 35
Stage I	89	0. 64	27	0. 70	31	0. 58	31	0. 65
Stage II	108	0. 47	29	0. 55	45	0. 53	34	0. 34
Stage III	102	0. 30	26	0. 22	42	0. 31	34	0. 35
Stage IV	35	0. 03	3	—	12	0. 08	20	0. 00
Unspecified	17	0. 19	0	—	10	—	7	—

*Rates not given for fewer than 10 patients, or for those with unspecified age. Data refer to patients with squamous cell tumors reviewed in detail, excluding 9 Connecticut and 7 Southwest Region patients with age unknown.

TABLE 8.—Five-year survival rates of patients with cervical cancer by specific morphologic features

	Combined series		Connecticut		Southwest Region, England	
	Number	5-year survival*	Number	5-year survival*	Number	5-year survival*
All tumors reviewed in detail	635	0. 45 ± 0. 02	277	0. 50 ± 0. 03	358	0. 40 ± 0. 03
Pattern						
Fingers	563	0. 44 ± 0. 02	236	0. 50 ± 0. 03	327	0. 40 ± 0. 03
Mixed (fingers and solid)	8	—	5	—	3	—
Solid	61	. 42 ± . 07	33	. 47 ± . 09	28	. 36 ± . 09
Not determined	3	—	3	—	0	—
Squamous-basal cell proportion (% squamous)						
0	8	—	8	—	0	—
25	20	. 54 ± . 11	16	. 62 ± . 12	4	—
50	36	. 38 ± . 09	25	. 48 ± . 11	11	. 18 ± . 12
75	457	. 47 ± . 02	190	. 52 ± . 04	267	. 43 ± . 03
100	114	. 35 ± . 05	38	. 36 ± . 08	76	. 34 ± . 05
Necrosis						
None	462	. 45 ± . 02	178	. 51 ± . 04	284	. 41 ± . 03
Slight	150	. 46 ± . 04	91	. 50 ± . 06	59	. 40 ± . 06
Moderate	16	. 36 ± . 12	7	—	9	—
Marked	7	—	1	—	6	—
Keratinous debris						

None	394	.44 ± .03	159	.47 ± .04	235	.41 ± .03
Slight	165	.46 ± .04	83	.59 ± .06	82	.33 ± .05
Moderate	45	.51 ± .08	22	.47 ± .11	23	.55 ± .11
Marked	30	.39 ± .09	13	.38 ± .13	17	.39 ± .12
Unspecified	1	—	0	—	1	—
Mitoses						
0–4 per high-power field	594	.46 ± .02	247	.53 ± .03	347	.41 ± .03
5+ per high-power field	41	.27 ± .07	30	.31 ± .09	11	.18 ± .12
Bizarre cells						
Inconspicuous	601	.45 ± .02	257	.50 ± .03	344	.41 ± .03
Conspicuous	34	.40 ± .09	20	.50 ± .11	14	.28 ± .12
Fibrosis						
Inconspicuous	87	.48 ± .06	48	.53 ± .08	39	.41 ± .08
Conspicuous	548	.44 ± .02	229	.50 ± .03	319	.40 ± .03
Plasma cells						
Inconspicuous	562	.43 ± .02	227	.49 ± .03	335	.40 ± .03
Conspicuous	73	.56 ± .06	50	.57 ± .07	23	.52 ± .10
Eosinophils						
Inconspicuous	586	.44 ± .02	244	.51 ± .03	342	.40 ± .03
Conspicuous	49	.52 ± .07	33	.49 ± .09	16	.56 ± .12
Differentiation						
Well differentiated	36	.49 ± .08	15	.53 ± .13	21	.45 ± .11
Average	529	.45 ± .02	230	.50 ± .03	299	.42 ± .03
Undifferentiated	67	.37 ± .06	29	.56 ± .10	38	.24 ± .07
Not determined	3	—	3	—	0	—

*Survival rates omitted where there were fewer than 10 patients. No adjustment made for differences in age distribution.

Of importance in table 8 is the superiority of the Connecticut survival rates over those in the SWR within almost every subcategory. Although the rates for many groups have relatively large standard errors, the regularity of this pattern is quite striking, and the two exceptions "keratinous debris moderate or marked" and "eosinophils conspicuous" could easily be a result of the small number observed. This pattern reinforces the conclusion stated earlier, that the difference in survival rates between Connecticut and the SWR must have some explanation other than differences in the histologic appearance of the cervical cancers.

DISCUSSION

There is no standard classification for the microscopic appearance of invasive cervical cancer beyond the usual division by histologic type and, to some extent, tumor grade. Although many investigators have reported on morbidity, metastases, or survival rates in relation to the microscopic appearance of cervical cancer, most studies have been based on classifications of tumor grade and have emphasized only those histologic characteristics of particular interest to the investigators (*4–9*). There are three notable features of the present study: It includes all known patients in a defined population for whom suitable pathologic material was available; it is based on classification of ten separate histologic features rather than only a few; and the pathologic classification of the tumors is related to 5-year survival rates.

Even though an effort was made by the two pathologists to apply the histologic classification in a uniform manner, there was a gradual change in the "average" classification of tumors, *within* each area, from the first slides reviewed to the last ones, and for 28 tumors inadvertently reviewed twice, agreement between the two readings was incomplete. There may be reasons for both observations other than changes in classification practices. For instance, in each area the rural hospitals were visited last, and since rural areas generally have lower incidence rates than urban areas there may be a real difference in tumor morphology; similarly, when two reviews were made of the same case they were usually based on different histologic sections. For these reasons, small differences in the histologic classification of the cervical cancers may not be significant.

In theory, these difficulties could have been reduced by collecting all histologic slides in a single laboratory and reviewing the combined Connecticut and SWR slides randomly. However, in practice this procedure presents many difficulties. The alternate procedure of visiting each hospital in each area, as in this study, has the advantage of allowing the reviewing pathologists to examine all histologic sections of each case together with the complete pathology reports and clinical records. This is particularly important in resolving cases of doubtful malignancy or cases in which the site of origin is uncertain.

The most striking feature of the data reported here is the difference in survival between patients with cervical cancer in Connecticut and those in the Southwest Region of England—a difference almost uniformly found regardless of patient age, tumor stage, or tumor morphology. There are several possible explanations for this difference. One explanation for the low survival of cervical cancer patients in the SWR compared with those in Connecticut is that in the latter group there might be a substantial proportion of noninvasive lesions. As already stated, microscopic criteria for the diagnosis of invasive cervical cancer were virtually identical in the two areas, so this explanation can be ruled out. A second possibility is that cervical cancer patients in the SWR delay seeking medical attention substantially longer than the patients in Connecticut and so have a higher proportion of tumors in advanced stages and, within each stage, a higher proportion of "late" as opposed to "early" tumors. However, as previously mentioned, the large difference in survival of patients with cervical cancer in the two areas contrasts sharply with a small difference in survival of patients with corpus cancer in the two areas. If the difference for cervical cancer were largely or entirely due to a difference in average tumor stage at the time of diagnosis, one would also expect some difference for corpus cancer also because of the similarities in symptoms. This argument is admittedly weak, but it does suggest that factors other than tumor stage may be operating.

The question naturally arises whether there is any significant difference between the two areas in the general treatment policy for cervical cancer or in the way various treatment methods are used. It is impossible to answer the latter question from the data at hand, but table 9 summarizes survival rates by stage and treatment as given in the Stockholm report (*3*). Surgery, with or without radiation, was used more often in the Northeastern United States than in Southern England, while radiation therapy alone was used more often in Southern England. Radiation-treated patients had similar survival rates in the two areas, but those treated by surgery in the United States lived longer than their English counterparts. It is unknown whether this reflects a difference in the extent or behavior of cervical cancer in the two countries, a difference in the method of selecting patients for surgery, or a difference in surgical skill and general medical support. However, the last possibility seems least likely because of the similarity in survival of corpus cancer patients, who are usually treated surgically.

Certain combinations of histologic features tended to occur with elevated frequency. For example, tumors with "conspicuous fibrosis" almost invariably had a "finger pattern," whereas "inconspicuous fibrosis" was generally found with a "solid pattern" (table 10). The relation between differentiation and percent squamous cells was somewhat more complex. There were two general ways by which a tumor could be classified as undifferentiated: by reason of a very low proportion of squamous cells or by reason of certain features, such as frequent mitoses or conspicuous

TABLE 9.—Percent distribution of cases and 5-year recovery rates, by stage and treatment*

Treatment and geographic area	Number of patients 1950–54	Percent distribution, by stage				5-year recovery rate, by stage†			
		I	II	III	IV	I	II	III	IV
Radiation only									
Southern England	1, 766	17. 0	43. 5	28. 9	10. 5	63. 0	42. 8	17. 6	5. 9
Northeastern United States	791	31. 6	38. 7	19. 7	10. 0	61. 2	42. 5	19. 2	2. 5
Surgery, with or without radiation									
Southern England	270	45. 6	37. 8	6. 7	10. 0	70. 7	43. 1	22. 2	11. 1
Northeastern United States	456	55. 5	34. 6	7. 0	2. 9	79. 4	56. 3	34. 4	*7. 7*

*Data from (*3*).

†Percent of patients known to be alive and cancer-free. Rate based on fewer than 15 cases in italics.

bizarre cells occurring in tumors with a high proportion of squamous cells. As a result, most undifferentiated tumors had either a high (100%) or a low (0% or 25%) proportion of squamous cells, whereas "well differentiated" and "average" tumors usually had an intermediate (50% or 75%) proportion of squamous cells (table 11).

TABLE 10.—Relationship between fibrosis and tumor pattern

Pattern	Total	Fibrosis	
		Inconspicuous	Conspicuous
Total	635	87	548
Solid	61	58	3
Mixed	8	5	3
Fingers	563	21	542
Indeterminate	3	3	0

TABLE 11.—Relationship between differentiation and proportion of squamous cells

Differentiation	Total	Proportion of squamous cells (%)				
		0	25	50	75	100
Total	635	8	20	36	457	114
Differentiated	36	0	0	1	34	1
Average	529	0	6	29	420	74
Undifferentiated	67	8	14	6	0	39
Not determined	3	0	0	0	3	0

Although neither tumor differentiation nor percent squamous cells showed a statistically significant relation to 5-year survival, one may ask whether certain *combinations* of these with other variables had any relation to survival. A very crude measure of this is to assess the four "possibly favorable" features for each squamous cell carcinoma (mild or absent necrosis; 75% or less squamous cells; conspicuous plasma cells; conspicuous eosinophils) and count the number present. The resulting score varied from zero to four. Table 12 shows that higher scores were associated with higher survival rates.

TABLE 12.—Survival in relation to a combination of morphologic features

Score*		Total patients	5-year survival rates
All patients		635	0. 45 ± 0. 02
Score	0	4	0 ± 0
	1	103	. 33 ± . 05
	2	437	. 46 ± . 02
	3	86	. 53 ± . 06
	4	5	. 75 ± . 22

*Number of the following features present: necrosis—mild or absent; squamous cell—less than 100 percent; plasma cell—conspicuous; eosinophils—conspicuous.

A later report will deal more fully with correlations between the histologic features studied, and with the relation between survival rates and combinations of histologic features.

SUMMARY

A combined pathologic and statistical survey of cancer of the uterus in Connecticut and the Southwestern Hospital Board Region of England was undertaken to study differences between cervical cancer incidence rates and the survival of patients with cervical cancer in the two areas. Diagnostic criteria for invasive uterine cancer were similar in the two areas. However, carcinoma *in situ* was reported much more often in Connecticut than in the Southwest Region, primarily because of more extensive vaginal cytology programs and more liberal criteria for diagnosis.

The histologic features of invasive epidermoid carcinoma of the cervix are similar in Connecticut and in the Southwest Region. Therefore the observed difference in survival rates cannot be explained by a difference in the histologic features of tumors in these areas. None of the ten histologic features studied had a statistically significant relation to 5-year survival, except that patients with carcinomas having 5 or more mitoses per high-power microscopic field had lower survival rates than other patients. In addition, there was a suggestive but not statistically significant relation between lower survival rates and four other histologic features: "100 percent squamous cells," "moderate or marked necrosis," "inconspicuous numbers of plasma cells," and "inconspicuous numbers of eosinophils." The most important cause of the observed difference in survival rates of patients with cervical cancer in Connecticut and the Southwest Region of England may be a difference in average tumor stage at the time of diagnosis.

Incidence rates for invasive cervical cancer have been declining in Connecticut in recent years, but there is no evidence of a decline in rates in the Southwest Region of England or of a decline in rates for corpus cancer in either area.

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Evaluation of Diagnostic Information Supporting Medical Certification of Deaths From Cardiovascular Disease [1]

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THE question of quality of reported diagnostic information frequently arises in the interpretation of mortality statistics of cardiovascular disease. Part of the problem is in the nature of the disease, which seldom occurs as a single diagnostic entity but as a complex of diseases that cannot be readily untangled in selecting a single cause of death for primary mortality tabulations. Other problems arise from the circumstances of death. Many deaths from cardiovascular disease occur suddenly, and there is some question of availability of adequate antemortem information. Data on these and allied questions, such as the extent to which associated diseases like diabetes and chronic obstructive lung diseases are reported on death certificates, will be presented from a study of a sample of death certificates.

The accuracy of diagnostic information on death certificates has been studied by many investigators. These studies have been generally limited to deaths on which hospital records or autopsy reports were available. Because deaths in hospitals and, more particularly, those for which autopsies are performed are a biased sample of all deaths, it would be difficult to generalize from the results of these studies to cardiovascular disease mortality data for the general population.

In 1956, a pilot study [2] was conducted to explore the use of death certificates in delineating possible relations of smoking, residence, and work histories to cancer of the lung. As part of this pilot study, additional information was collected from certifying physicians to determine the possibilities of developing measures of quality of medical certifications of deaths for the general population. The feasibility of obtaining additional information useful for the evaluation of diagnostic data on death certificates was established in this pilot study. However, the questionnaire used was not completely satisfactory in eliciting clinical evidence for the validation of cardiovascular and renal diagnoses.

[1] Presented at the Harold F. Dorn Memorial Session on November 13, 1963, at the ninety-first annual meeting of the American Public Health Association, Kansas City, Mo.

[2] MORIYAMA, I. M., BAUM, W. S., HAENSZEL, W. M., and MATTISON, B. F.: Inquiry into diagnostic evidence supporting medical certifications of death. Amer J Pub Health 48: 1376–1387, 1958.

METHODOLOGY

In this follow-back study conducted by the National Vital Statistics Division, a national sample of deaths occurring in July and August, 1960, was drawn from the 10 percent Current Mortality Sample. A questionnaire was sent to the physician, coroner, or medical examiner signing the death certificate and to hospitals and other medical practitioners referred to by the medical certifier as possible additional sources of diagnostic information. The primary aim of the questionnaire was to secure information on the diagnostic methods used and pertinent findings on which the medical certification of death was based. Data were also obtained on the circumstances surrounding sudden and unexpected deaths and presence or absence of associated diseases, such as diabetes, hypertension, renal diseases, and chronic obstructive pulmonary diseases.

The returns were systematically reviewed by two cardiologists (TRD and WBK) to determine whether the cause of death that had been assigned was supported by the diagnostic information provided by the certifier. When the evidence supported another diagnosis, it was indicated by the reviewers, and the preferred diagnosis was assessed in the same manner as the original certified diagnosis. When additional diagnostic information was available from other referral sources, a similar assessment was made on the basis of all available data.

The following classification of validity of medical certification was used by the reviewers:

1) Diagnosis well established
2) Reported evidence incomplete, but diagnosis reasonable
3) No diagnostic evidence for evaluation, but reasonable inference
4) Evidence insufficient to support any diagnosis of underlying cause
5) Reported evidence incomplete, and diagnosis probably incorrect
6) Another diagnosis well established
7) No useful response

The criteria for the first 2 categories of this classification are shown in table 1 for the various diagnostic rubrics. The criterion for category 3 was the lack of any history or evidence to contradict the diagnosis, except in instances where the following criteria were used:

420. Arteriosclerotic heart disease, including diseases of coronary arteries

    Adult found dead, but death not established as sudden, and no evidence to suggest other cause

450. Generalized arteriosclerosis

    Senile patient with chronic downhill course with no specific arteriosclerotic manifestations of coronary or cerebral thrombosis or gangrene

TABLE 1.—Criteria for evaluation of diagnosis

Diagnosis	Diagnosis well established	Reported evidence incomplete, but diagnosis reasonable
331. Cerebral hemorrhage and cerebrovascular accident	Sudden onset of hemiplegia and/or coma with spinal fluid or postmortem evidence	Hemiplegia and/or coma without spinal fluid or postmortem evidence
332. Cerebral embolism and thrombosis	Sudden onset of hemiplegia and/or coma with spinal fluid examination, evidence of source of embolism or other embolic phenomenon, or postmortem evidence	Sudden onset of hemiplegia and/or coma, but no spinal fluid examination, no source of embolism, or no autopsy
334. Other and ill-defined vascular lesions	Senile individual with marked mental changes without localizing neurological findings, and no other cause for cerebral manifestations than presumed cerebral arteriosclerosis	Less clear than criteria for well-established diagnosis
416. Other heart disease specified as rheumatic	Diagnosed by pathological murmurs, or atrial fibrillation ascribed to rheumatic heart disease, with or without history of rheumatic fever, with postmortem or radiological findings	No history of rheumatic fever, or less definite murmurs suggestive of rheumatic heart disease, and/or arrhythmia suggestive of atrial fibrillation, and no appropriate ECG or radiological findings
420.0 Arteriosclerotic heart disease, so described	Documented myocardial infarction, coronary insufficiency, angina pectoris, and sudden death with autopsy evidence	Possible but not well-established myocardial infarction, coronary insufficiency, angina pectoris, or sudden, unexpected death without autopsy, or congestive heart failure in adults without other apparent etiology
420.1 Heart disease specified as involving coronary arteries	Same as for 420.0, except for exclusion of angina pectoris	Possible but not well-established myocardial infarction or coronary insufficiency, or angina pectoris specified as due to coronary disease, or sudden death, with no autopsy performed
420.2 Angina pectoris	Definite angina pectoris documented	Doubtful angina pectoris
422. Other myocardial degeneration	Evidence of heart failure and/or arrhythmia, ECG abnormalities, autopsy findings consistent with degenerative changes in the myocardium	Less concrete evidence of items in "well-established" diagnosis
434. Other and unspecified disease of heart	Evidence of enlarged heart and dyspnea,paroxysmal nocturnal dyspnea with or without edema, and symptoms of pulmonary congestion in absence of primary pulmonary disease	Evidence of items in well-established diagnosis, but incomplete

781-871—65——27

Table 1.—Criteria for evaluation of diagnosis—Continued

Diagnosis	Diagnosis well established	Reported evidence incomplete, but diagnosis reasonable
443. Other and unspecified hypertensive heart disease	Long-standing hypertension with evidence of cardiac enlargement and/or congestive heart failure	Known hypertension; less clear-cut evidence of heart failure and/or enlargement
446. Hypertension with arteriolar nephrosclerosis	Clear-cut evidence of significant and long-term antecedent elevated blood pressure and renal failure as demonstrated by laboratory tests	Less clear-cut evidence of hypertension and renal disease
450. Generalized arteriosclerosis	Autopsy evidence	X ray and/or clinical evidence

It was not feasible to formulate any clinical criteria for the other categories, and the reviewers used their judgment in classifying cases to the appropriate categories, 4 through 7.

RESULTS

The national sample consisted of 1,362 death certificates on which the underlying cause had been coded as a cardiovascular death according to the International rules for classifying causes of death. Eighty-seven percent of the medical certifiers returned a questionnaire with some kind of response. The response rate would have been somewhat higher if the returns from referral sources had been included. The response rate for coroners and medical examiners was almost identical to that for medical practitioners.

Of the responses received from medical certifiers, about 14 percent were judged by the reviewers to contain no useful information for evaluation of diagnostic data. These were returns that reiterated the diagnostic data already reported on death certificates and did not contribute to further understanding of the basis for the medical certification. The proportion of "no useful response" was the same whether the death was certified by a medicolegal authority or by a medical practitioner. Further queries to the medical certifier might have elicited some useful response but were not considered feasible, because the diagnostic evaluation was made some time after the data were collected. It is estimated from other follow-back experience involving demographic variables that some useful response would have been received in about one half of the cases had a query been sent. However, past experience indicated that the returns from such a query would tend to be poorer and would likely be evaluated at the lower end of the scale, that is, assigned to the classes "insufficient evidence to support any diagnosis" or "diagnosis incorrect." Therefore, the non-useful responses were kept as a separate category.

On the basis of diagnostic data provided by the medical certifier, and *including* the nonresponses in the base, the reviewers judged that about 12 percent of the diagnoses classified as the underlying cause of death were well established as one of the cardiovascular-renal diseases. In an additional 27 percent, the diagnosis appeared reasonable although the reported evidence was incomplete. In another 14 percent, there was no history or evidence to contradict a diagnosis of a cardiovascular disease, and these were considered to be reasonable inferences.

In order to arrive at an estimate of the total percentage of reasonable inference, or better, for the cardiovascular-renal deaths as a whole, it is necessary to take into consideration those diagnoses that were judged to be "probably incorrect" or "another diagnosis well established" when the preferred diagnosis was, in fact, another disease of the cardiovascular-renal system. In over 95 percent of the diagnoses judged to be incorrect, the preferred diagnosis of the reviewers was another cardiovascular-renal disease. Taking into account the various factors, it is estimated that in at least two thirds of the deaths attributed to cardiovascular-renal diseases in the United States, a diagnosis of "cardiovascular-renal disease" would be a reasonable inference or better. The "true" estimate is higher than this figure, but it is difficult to derive a reasonable estimate from this study because in about one fifth of the cases the evidence presented was insufficient to support any diagnosis, or the responses were incomplete or otherwise not useful for evaluation purposes. These estimates assume that the nonrespondents in the survey would contribute nothing to the quality of diagnostic information even if pressed to do so. This is an extreme assumption. At the other extreme is the finding that less than 1 percent of the deaths attributed to a cardiovascular-renal disease was judged by the reviewers to be clearly incorrect.

The evidence supporting the diagnosis of the medical certifier varied considerably in terms of completeness and quality according to the specific disease involved (*see* table 2). Again, if one takes the level of reasonable inference or better, the range was 30 percent for "other myocardial degeneration" to 74 percent for arteriosclerotic heart disease, including diseases of coronary arteries. The corresponding proportion for heart disease specified as disease of coronary arteries was 80 percent. About 60 percent of the diagnoses of rheumatic fever and rheumatic heart disease, 54 percent of the deaths certified as cerebrovascular diseases, and close to 50 percent of the certification of hypertensive heart disease and "other heart disease" were considered to be reasonably supported by diagnostic information returned in the questionnaire.

One apparent reason for the relatively poor quality of diagnostic evidence on which medical certifications of specific cardiovascular diseases are based is the problem of diagnosis and determining, in decedents of advanced age, which of the multiple diagnoses was the underlying cause of death. Although the frequency of deaths in the age group under 65 years of age is relatively small for many of the disease categories, the percentage of diagnoses rated "inference reasonable" or better was generally higher

TABLE 2.—Consistency of medical certification with diagnostic evidence provided by medical certifier by age of decedent: United States weighted sample*, July and August, 1960

Diagnostic category and age	Total deaths		Evaluation						
	Number	Percent	Diagnosis well established	Reported evidence incomplete, but diagnosis reasonable	No diagnostic evidence for evaluation, but reasonable inference	Evidence insufficient to support any diagnosis	Evidence incomplete and diagnosis probably incorrect	Another diagnosis well established	No useful response in the survey
Vascular lesions affecting central nervous system (330–334)	429	100.0	7.2	29.6	17.5	14.5	11.0	3.7	16.6
Under 45	13	100.0	7.7	38.5	7.7	7.7	23.1	7.7	7.7
45–64	80	100.0	18.8	28.8	10.0	12.5	10.0	3.8	16.3
65–84	288	100.0	2.1	30.2	19.8	15.6	10.4	4.2	17.7
85 and over	48	100.0	18.8	25.0	18.8	12.5	12.5	0	12.5
Rheumatic fever and chronic rheumatic heart disease (400–416)	52	100.0	36.5	9.6	13.5	1.9	17.3	3.8	17.3
Under 45	7	100.0	28.6	28.6	14.3	0	0	14.3	14.3
45–64	24	100.0	33.3	12.5	12.5	4.2	12.5	4.2	20.8
65–84	21	100.0	42.9	0	14.3	0	28.6	0	14.3
85 and over	—	—	—	—	—	—	—	—	—

Arteriosclerotic heart disease including coronary disease (420)	1, 199	100. 0	17. 6	40. 9	15. 5	4. 7	4. 9	2. 3	14. 1
Under 45	39	100. 0	25. 6	51. 3	17. 9	2. 6	0	0	2. 6
45–64	344	100. 0	22. 7	45. 9	12. 8	2. 9	3. 2	2. 0	10. 5
65–84	699	100. 0	16. 3	40. 3	16. 7	4. 7	4. 3	2. 6	15. 0
85 and over	117	100. 0	7. 7	25. 6	15. 4	10. 3	15. 4	2. 6	23. 1
Other myocardial degeneration (422)	114	100. 0	2. 6	14. 0	13. 2	14. 0	29. 8	16. 7	9. 6
Under 45	1	100. 0	0	0	0	0	0	100. 0	0
45–64	20	100. 0	0	5. 0	15. 0	20. 0	35. 0	15. 0	10. 0
65–84	72	100. 0	4. 2	20. 8	16. 7	16. 7	12. 5	20. 8	8. 3
85 and over	21	100. 0	0	0	0	0	85. 7	0	14. 3
Hypertensive disease (440–447)	232	100. 0	13. 8	19. 8	14. 7	11. 2	17. 7	10. 3	12. 5
Under 45	10	100. 0	40. 0	10. 0	10. 0	0	10. 0	20. 0	10. 0
45–64	48	100. 0	20. 8	18. 8	12. 5	4. 2	20. 8	8. 3	14. 6
65–84	150	100. 0	10. 0	22. 0	16. 0	10. 0	18. 0	10. 0	14. 0
85 and over	24	100. 0	12. 5	12. 5	12. 5	37. 5	12. 5	12. 5	0
Other (421, 430–434, 450–456, 460–468, 590–594)	225	100. 0	13. 3	16. 9	17. 8	6. 7	17. 3	10. 2	17. 8
Under 45	11	100. 0	27. 3	9. 1	18. 2	0	9. 1	27. 3	9. 1
45–64	46	100. 0	19. 6	15. 2	10. 9	0	23. 9	10. 9	19. 6
65–84	114	100. 0	10. 5	15. 8	15. 8	7. 9	15. 8	10. 5	23. 7
85 and over	54	100. 0	11. 1	22. 2	27. 8	11. 1	16. 7	5. 6	5. 6

*Proportional weighted sample by age and color.

than that for all ages. For arteriosclerotic heart disease, the largest component of cardiovascular-renal diseases, 95 percent of the diagnoses for decedents 25 to 44 years and about 80 percent of the diagnoses for decedents 45 to 64 years of age were judged to be a reasonable inference or better.

As previously mentioned, it was estimated that in 70 to 75 percent of the deaths assigned to cardiovascular-renal diseases, a diagnosis of "cardiovascular-renal disease" would be a reasonable inference or better. For the age group under 65 years, the corresponding estimate is about 80 percent, and for those 65 years and over, about 70 percent would be a reasonable diagnosis.

The greater complexity of diagnostic data in the older ages is probably linked with the medical problem presented by these patients. The patient's condition may be such that aggressive attempts to reach a definitive diagnosis are not made because they would not be helpful in treatment. Also, in the elderly, many chronic conditions are involved and the medical certifier is faced with the difficult, and frequently impossible, problem of determining the underlying cause of death and the sequence that led to death.

Evaluation Based on Diagnostic Information from Various Sources

In a little more than one third of the deaths, additional diagnostic information was received from another physician who had previously attended the patient and/or from a hospital where the patient was treated at one time or other. Frequently, responses were received from two referral sources and, in a small proportion of cases, from three sources.

After the completion of the diagnostic evaluation based on information provided by the medical certifier, information from all other sources was reviewed. In this phase of the evaluation, the reviewers assessed all available information for what they themselves interpreted to be the underlying cause of death.

The results of this evaluation (table 3) indicate that, when more evidence is brought together, there is a better basis for judgment. Compared with the evaluation based on medical certifier's evidence, the proportion of diagnoses "well established" increased from 12 to 19 percent, and "diagnosis reasonable" increased from 27 to 39 percent. However, there was little change in the proportion of diagnoses of a cardiovascular-renal disease judged to be a reasonable inference or better.

Where another diagnosis was well established or the diagnosis was judged to be "probably incorrect" according to the medical certifier's evidence, the death was allocated to the proper diagnostic category. This resulted in some changes, particularly in the number of deaths attributable to vascular lesions affecting the central nervous system, arteriosclerotic heart disease, and other diseases of the coronary arteries. The total number of deaths assigned to diseases of the cardiovascular-renal system also increased by 105 deaths, which represents the cases where the medical certifier did not return a questionnaire but some information was received

TABLE 3.—Evaluation of all available evidence and reviewers' assessment of underlying cause of death: United States weighted sample,* July and August, 1960

Diagnostic category	Total deaths		Evaluation				
	Number	Percent	Diagnosis well established	Reported evidence incomplete, but diagnosis reasonable	No diagnostic evidence for evaluation, but reasonable inference	Evidence insufficient to support any diagnosis	No useful response in the survey
Vascular lesions affecting central nervous system (330–334)	449	100. 0	14. 3	41. 4	17. 4	15. 4	11. 6
Rheumatic fever and chronic rheumatic heart disease (400–416)	53	100. 0	47. 2	26. 4	13. 2	1. 9	11. 3
Arteriosclerotic heart disease including coronary disease (420)	1, 257	100. 0	21. 6	47. 8	16. 4	3. 7	10. 5
Arteriosclerotic heart disease so described (420.0)	542	100. 0	18. 5	44. 6	19. 9	5. 0	12. 0
Other coronary disease (420.1, 420.2)	715	100. 0	23. 9	50. 2	13. 7	2. 8	9. 4
Chronic endocarditis not specified as rheumatic (421)	17	100. 0	5. 9	47. 1	47. 1	0	0
Other myocardial degeneration (422)	120	100. 0	14. 2	41. 7	19. 2	15. 8	9. 2
Other diseases of heart (430–434)	55	100. 0	10. 9	52. 7	18. 2	5. 5	12. 7
Hypertensive heart disease (440–443)	198	100. 0	27. 8	33. 8	19. 7	10. 6	8. 1
Other hypertensive disease (444–447)	36	100. 0	22. 2	38. 9	5. 6	16. 7	16. 7
General arteriosclerosis (450)	88	100. 0	6. 8	42. 0	19. 3	10. 2	21. 6
Other diseases of arteries (451–456)	15	100. 0	66. 7	0	6. 7	0	26. 7
Diseases of veins and other diseases of circulatory system (460–468)	25	100. 0	56. 0	44. 0	0	0	0
Nephritis and nephrosis (590-594)	43	100. 0	32. 6	18. 6	18. 6	20. 9	9. 3

*Proportional weighted sample by age and color.

from a referral source. In other words, usable diagnostic information was obtained from other sources in about 28 percent of the cases where the medical certifier did not respond.

Medicolegal Deaths and Their Effect on Over-All Quality

The laws of the various States specify the circumstances, *e.g.*, deaths without medical attendance, sudden and unexpected deaths, etc., under which deaths come under the purview of the medicolegal authorities. In the present study, about 14 percent of all deaths attributed to cardiovascular-renal diseases were certified by a coroner or medical examiner. This proportion varied considerably by diagnostic category. For example, about 7 percent of deaths assigned to vascular lesions affecting the central nervous system were coroner or medical examiner cases. On the other hand, about 38 percent of "other diseases of heart" were certified by a coroner or medical examiner. However, the frequencies were relatively small for all disease categories except diseases of the coronary arteries. About 10 percent of the deaths from arteriosclerotic heart disease and 21 percent of the deaths from heart disease specified as involving coronary arteries and angina pectoris were medicolegal cases. With regard to arteriosclerotic heart disease, including diseases of the coronary arteries, the proportion of diagnoses that were solidly established as certified by the medical practitioner was about 17 percent as compared with 12 percent for the coroner or medical examiner. On the other hand, the percentages of "reasonable diagnoses" and "reasonable inferences" were higher for the medicolegal certifications. At the level of "reasonable diagnosis" or better, there was no significant difference in the quality between the medical practitioner and medicolegal certifications. At a somewhat lower level of acceptance, that is, "reasonable inference" or better, the proportion of cases was higher for medicolegal certifications as compared with that for the medical practitioners. This was also true for cardiovascular-renal disease mortality as a whole.

Sudden Death

One item on the questionnaire related to sudden death and the time interval between the onset of acute episode and death. In the classification of this item, sudden death was defined as an event occurring less than 1 hour after an acute episode. According to this definition, 20 percent of the deaths from cardiovascular-renal diseases were "sudden deaths." In about one half of this proportion, there was indication of prior coronary heart disease or the existence of some other disease that might have possibly ended in fatality. On the basis of these figures, about 10 percent of the deaths from cardiovascular-renal diseases may be considered "sudden" and *unexpected* deaths. In addition, about 4 percent of the decedents were reported to have been "found dead," and of these, one half were known to have a disease of the coronary arteries or some other potentially fatal disease. Thus, one half of those dying suddenly and

decedents found dead were known to have had coronary artery disease or some other potentially fatal disease.

Although medical information on sudden and unexpected deaths is frequently sketchy, the circumstances of the death, the presence of a responsible witness in many cases, and other information generally fit in with the present concept of sudden and unexpected deaths from certain cardiovascular diseases, the diseases of coronary arteries in particular. Therefore, a large proportion (about 80%) of the diagnoses relating to sudden and unexpected deaths were rated as "reasonable inference" or better.

Associated Diseases

The instructions for completing the medical certification of causes of death call for the sequence of morbid events leading to death and for diseases contributing to the death but not related to the disease causing death. In order to obtain some idea of the extent to which diseases present at the time of death are reported on death certificates within this framework, items were introduced into the questionnaire concerning the presence or absence of diabetes and hypertension, and of certain chronic respiratory diseases, namely, bronchiectasis, chronic bronchitis, emphysema, and bronchial asthma.

The questionnaire returns indicated that 14 percent of those dying from "cardiovascular-renal diseases" were diabetics, but only 25 percent of the death certificates for these decedents mentioned diabetes. The proportion of cardiovascular-renal deaths in which diabetes was reported as an associated disease (about 4%) was about the same as that found in a special study of multiple causes of death for the data year 1955.

About 40 percent of those that died from cardiovascular-renal diseases were reported to be hypertensives. Although a count was not made of the number of hypertensive diseases reported on death certificates for this study population, hypertension was probably underreported on death certificates. (A hypertensive disease was mentioned on death certificates for about 23% of the cardiovascular-renal deaths in 1955.)

Of the hypertensives identified in this study, the usual systolic blood pressure prior to terminal illness was specified to be 160 mm or more and/or the diastolic pressure was given as 95 or more in about 80 percent of the cases. No blood pressure readings were given for 13 percent of the reported hypertensives. In about 6 percent of the cases, the systolic pressure ranged from 140 to 159 and/or the diastolic pressure from 90 to 95. In about 1 percent, the reported systolic and diastolic pressures were less than 140 and 90, respectively.

The questionnaires also showed the presence of one or more chronic respiratory diseases. The following is a list of specified diseases expressed as percentages of total cardiovascular-renal deaths:

Asthma	5 percent
Bronchiectasis	3 percent

Chronic bronchitis	8 percent
Emphysema	18 percent

These estimates of associated diseases may be regarded as the minima because these particular items were not answered in the questionnaire for 800 to 900 deaths. In the reporting of associated chronic respiratory diseases on death certificates, no mention was made of bronchiectasis or chronic bronchitis, and less than 1 percent of the medical certifications contained reports of emphysema or asthma. These numbers were significantly smaller than expected on the basis of the 1955 multiple-cause tabulations of mortality data. Had the present study been based on deaths occurring in the winter months rather than in July and August, it is possible that the chronic respiratory diseases would have been reported with greater frequency.

Since the medical certifier is not required to report associated diseases unless they contribute to death, these results underscore the fact that the present form of medical certificate is not designed to elicit information on diseases present at the time of death. This has implications for multiple-cause studies based on the current medical certificate form *if* the purpose of the study is to obtain counts of diseases present at the time of death.

DISCUSSION

The question of accuracy of clinical and pathological observations and interpretation of findings from various tests and examinations is obviously a crucial one from the standpoint of precision of diagnosis. This study does not deal with this question. It accepts the reported findings unless they are inconsistent with other presumed facts, or the reported findings cannot result from the particular diagnostic procedures used.

The study attempts to assess the quality of medical certification of cardiovascular-renal deaths based on diagnostic information supplied by the medical certifier and by referral sources. The satisfactory assessment of quality of medical certification is in itself a difficult problem. It depends on how precisely and completely pertinent information needed for evaluation is communicated to the reviewers. It also depends on the criteria established to evaluate the evidence presented as a basis for the medical certification and on the ability of the reviewers to apply these criteria precisely and consistently.

The quality of medical certification of cardiovascular diseases in the United States cannot be determined with precision from the results of this survey. In about one fifth of the cases, the reported evidence was insufficient to support any diagnosis, or the responses were incomplete or otherwise not useful for evaluation purposes. In addition to this, no returns were received from 13 percent of the physicians queried. In view of the fact that the returns on about one third of the total deaths in the sample represent nonuseful responses, any estimate of quality of medical

certification based on this survey will be subject to large variation. As a minimum figure, it is estimated that in at least two thirds of the deaths attributed to cardiovascular-renal diseases, a diagnosis of "cardiovascular-renal disease" would be a reasonable inference or better.

The difficulty of determining the proper underlying cause sequence on the part of the medical certifier appears to be a significant factor affecting diagnostic quality. This is a special problem in the elderly for whom it is frequently impossible to ascertain which of the diseases present actually led to death. The identification of the underlying cause is often arbitrary and based on incomplete knowledge of causation in cardiovascular diseases. If decedents over 65 years of age are excluded from consideration, the rated quality is considerably higher than that for the total. This is especially true for arteriosclerotic heart disease, including diseases of coronary arteries.

The results of this study indicate the availability of more diagnostic data than were supplied by the medical certifier. The impression gained by the reviewers in the evaluation process was that, in many instances, the medical certifier was not the attending physician. This is possible, especially in hospitals, where medical certifications may be made by others than those treating the patient. Even outside of hospitals, the attending physician often may not be available at the time of death. This raises a problem of communication between the medical certifier and others with knowledge of the case. Another possible problem in this study is that in answering the questionnaire the medical certifier may have thought that he was to report only findings based on his personal observations.

If improvement in the quality of medical certification is to be sought, it would seem important to determine, in a definitive manner, how much diagnostic information is available to the medical certifier at the time he completes the death certificate. When the death certificate was first promulgated, the medical certifier was usually the attendant, a family physician with considerable familiarity with the patient and his illnesses. With the change in pattern of medical care, it is no longer an easy matter to identify the attending physician, nor is there any assurance that the medical certifier has all the pertinent information required to make out a medical certification properly. There is even some question about the medical certifier being the person who actually entered the cause-of-death information on the death certificate. A study should be made of the relationship between the decedent and the medical certifier and of the various arrangements established for the certification of causes of death so that a system can be set up to make maximum utilization of diagnostic data available from various sources.

The results of this study argue strongly that there should be another basis for the compilation of mortality statistics. The underlying cause concept is often difficult, if not impossible, to apply to cardiovascular-renal diseases. More useful and supportable data will probably be obtained through the tabulation of disease complexes and of associations between diseases. However, it should be clear from this study that only a small

proportion of associated diseases present at death is reported on death certificates as contributing to death. A re-examination of the basic concept of causes of death is needed before further work is undertaken on the mechanics of coding, such as those involved in the coding of multiple diagnoses.

The results of this study indicate that there should be further development of techniques to elicit needed information for evaluation of diagnostic information. In many instances, the structured type of questionnaire seemed unappealing to the respondent. Too many returns were vague and ambiguous. This problem may be overcome to some extent by queries.

Although a mail questionnaire survey has many advantages, a serious limitation is the lack of assurance that all available facts are completely and precisely reflected in the questionnaire returns. Because of this limitation, the results are likely to be understatements rather than exaggerations of the quality of medical certification.

Reviewing and assessing the quality of diagnostic information on cardiovascular diseases are tedious and difficult to accomplish in a consistent manner. Postmortem examinations are infrequently made, and conclusive laboratory, clinical, or pathological findings are not generally reported. Considerable clinical judgment is required in piecing together reported information, which is often fragmentary, to form what appears to be the most likely clinical picture. How well this can be done through mail questionnaires, in diseases like those of the circulatory system, should be tested through interviews with the medical certifier and others familiar with the case.

SUMMARY

Questionnaries were sent to the medical certifiers and others with knowledge of the case on a national sample of 1,362 cardiovascular-renal disease deaths to secure information on diagnostic methods used and pertinent findings on which the medical certification of death was based. Data were also obtained on sudden and unexpected deaths and presence or absence of associated diseases. The returns were reviewed and determination made as to whether the assigned cause of death was supported by diagnostic data provided by the certifier.

It is estimated that from 70 to 75 percent of deaths classified as cardiovascular disease in the United States may be considered as a reasonable inference or better. With a higher rate of usable response, this estimate would have been somewhat higher. About 10 percent of deaths from cardiovascular diseases were sudden and unexpected deaths.

Large proportions of related diseases such as diabetes and certain chronic bronchopulmonary diseases were not reported on death certificates as contributing to death.

More study is needed on methods of eliciting complete responses through mail questionnaires, and to determine in a definite manner how much diagnostic information is actually available to the medical certifier at the time the death certificate is completed.

Underlying and Contributory Causes of Death

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This is a sequel to a previous note,[3] in which I discussed the problems that arise when the International Classification of Diseases is used for mortality statistics, for morbidity statistics, and for indexing hospital records. The argument was developed that these purposes could be served successfully only if certain principles of classification were observed. Two essential steps must be kept separate: (*a*) the construction of a classified list of diagnoses and (*b*) the development of principles and procedures for using this classification for indexing records and coding and tabulating morbidity and mortality statistics. I proposed the following principles as a basis for preparing the eighth revision of the International Statistical Classification:

1) The International Statistical Classification should be a classified list of single diagnostic terms, as used in medical practice.

2) Methods for coding, tabulating, and presenting morbidity and mortality statistics should be considered as a separate problem from the revision of the classified list of diagnoses, although naturally related to it.

3) The necessity for coding more than one diagnosis when two or more are entered on the death certificate should be explicitly recognized.

A single diagnosis, no matter how selected, no longer adequately represents the medical conditions that contribute to death in the United States and similar countries. Table 1 illustrates this fact with data obtained by coding a maximum of five diagnoses for a sample of deaths that occurred during 1955 in the United States. For certain selected diagnoses or groups of diagnoses, this table shows the number of death certificates on which these diagnoses were entered, the number of deaths for which they were selected as the underlying cause, and the number of deaths for which they were considered to be a contributory cause.

The selection of a single cause discarded about one half of the diagnostic information entered on death certificates in 1955, since the 1,528,000 death certificates had 2,911,000 codable diagnoses. The percentage

[1] Deceased, May 1963.

[2] National Institutes of Health, Public Health Service, U.S. Department of Health, Education, and Welfare.

[3] Dorn, H. F.: Some considerations in the revision of the International Statistical Classification. Pub Health Rep 79: 175–179, 1964.

TABLE 1.—Number of deaths for which selected diseases were coded as underlying and as contributory causes of death, United States, 1955

International List Nos., 7th revision	Diagnosis	Number of death certificates with diagnosis	Number of deaths for which diagnosis was selected as: Underlying cause	Contributory cause	Number underlying as percent of total
001–019	Tuberculosis	21, 331	14, 779	6, 552	69. 3
020–029	Syphilis	6, 735	3, 825	2, 910	56. 8
030–138	Other infective and parasitic diseases	14, 353	8, 028	6, 325	55. 9
140–205	Cancer	252, 621	234, 752	17, 869	92. 9
210–239	Benign and unspecified neoplasms	8, 342	5, 278	3, 064	63. 3
241	Asthma	13, 047	5, 904	7, 143	45. 3
260	Diabetes mellitus	61, 909	25, 217	36, 692	40. 7
290–293	Anemias	16, 075	3, 112	12, 963	19. 4
330–334	Vascular lesions affecting central nervous system	304, 004	173, 541	130, 463	57. 1
340	Meningitis	3, 558	1, 796	1, 762	50. 5
400–402	Rheumatic fever	1, 812	1, 126	686	62. 1
410–416	Chronic rheumatic heart disease	25, 130	18, 823	6, 307	74. 9
420.0	Arteriosclerotic heart disease so described	182, 164	156, 648	25, 516	86. 0
420.1	Heart disease involving coronary arteries	326, 248	245, 633	80, 615	75. 3
420.2	Angina pectoris	4, 549	1, 055	3, 494	23. 2
421	Chronic endocarditis not specified as rheumatic	12, 034	7, 094	4, 940	58. 9
422	Other myocardial degeneration	97, 795	58, 305	39, 490	59. 6
430–434	Other diseases of heart	106, 270	20, 852	85, 418	19. 6
440–443	Hypertensive heart disease	120, 701	73, 458	47, 243	60. 9
444–447	Hypertension without mention of heart disease	91, 301	11, 316	79, 985	12. 4
450	General arteriosclerosis	241, 628	32, 207	209, 421	13. 3
451–456	Other diseases of arteries	23, 214	7, 379	15, 835	31. 8
460–468	Diseases of veins, etc.	37, 063	4, 926	32, 137	13. 3
480–483	Influenza	3, 600	2, 719	881	75. 5
490–493	Pneumonia	116, 579	42, 173	74, 406	36. 2

500	Bronchitis, acute	2, 179	1, 067	1, 112	49. 0
501–502	Bronchitis, other	5, 876	2, 025	3, 851	34. 5
525	Other chronic interstitial pneumonia	6, 212	2, 289	3, 923	36. 8
526	Bronchiectasis	5, 363	2, 197	3, 166	41. 0
527.1	Emphysema without mention of bronchitis	12, 411	3, 902	8, 509	31. 4
527.0, 527.2	Other diseases of lung	16, 814	2, 129	14, 685	12. 7
540, 541	Ulcers of stomach and duodenum	16, 413	9, 784	6, 629	59. 6
543, 571, 572	Gastritis, enteritis, colitis	13, 708	7, 827	5, 881	57. 1
550–553	Appendicitis	2, 822	2, 223	599	78. 8
560, 561, 570	Hernia and intestinal obstruction	26, 549	8, 678	17, 871	32. 7
581	Cirrhosis of liver	25, 175	16, 630	8, 545	66. 1
590, 591	Nephritis, acute	6, 119	2, 393	3, 726	39. 1
592–594	Nephritis, other	29, 876	16, 186	13, 690	54. 2
640–689	Complications of pregnancy and puerperium	3, 012	1, 813	1, 199	60. 2
722	Rheumatoid arthritis	6, 511	977	5, 534	15. 0
720–721, 723–725	Arthritis, other	7, 588	699	6, 889	9. 2
750–759	Congenital malformations	30, 653	20, 932	9, 721	68. 3
760–762	Birth injury, asphyxia	35, 320	28, 938	6, 382	81. 9
763–768	Infections of newborn	6, 621	4, 240	2, 381	64. 0
769–776	Other diseases of early infancy	34, 865	30, 986	3, 879	88. 9
810–835	Motor vehicle accidents	38, 788	38, 401	387	99. 0
800–802, 840–962, 965	Accidents, other	80, 005	55, 672	24, 333	69. 6
963–964, 970–985	Suicide, homicide	23, 989	23, 816	173	99. 3

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TABLE 2.—Number of deaths by age, sex, and selected diagnoses classified as the underlying or contributory cause of death, white population, United States, 1955

International List Nos., 7th revision	Diagnosis and sex	Total	0–4	5–14	15–24	25–34	35–44	45–54	55–64	65–74	75–84	85+	Not stated
330–334	Vascular lesions affecting central nervous system:												
	Male:												
	Underlying	73, 805	107	135	122	425	1, 286	3, 689	10, 020	22, 943	25, 373	9, 669	36
	Contributory	59, 148	710	602	1, 145	1, 140	1, 573	3, 537	9, 291	18, 791	17, 238	5, 068	53
	Female:												
	Underlying	78, 353	120	82	160	392	1, 137	3, 427	8, 163	20, 735	30, 188	13, 873	76
	Contributory	58, 041	565	279	335	486	1, 173	2, 842	6, 864	17, 099	20, 269	8, 079	50
400–402	Rheumatic fever:												
	Male:												
	Underlying	481	11	99	72	43	65	60	59	47	23	2	0
	Contributory	306	2	22	40	35	32	66	48	52	7	2	0
	Female:												
	Underlying	434	4	113	43	52	41	52	47	43	35	4	0
	Contributory	306	2	36	41	17	37	42	45	34	42	10	0
410–416	Chronic rheumatic heart disease:												
	Male:												
	Underlying	8, 468	7	18	195	601	1, 182	1, 702	2, 124	1, 629	849	161	0
	Contributory	3, 105	7	14	42	112	308	548	757	753	466	98	0
	Female:												
	Underlying	8, 713	2	14	195	582	1, 078	1, 864	1, 898	1, 640	1, 010	428	2
	Contributory	2, 819	2	5	55	117	262	451	601	711	480	135	0
420.0	Arteriosclerotic heart disease so described:												

	Male:													
	Underlying	79, 755	4	0	10	64	716	3, 920	12, 667	25, 719	26, 240	10, 339	76
	Contributory	12, 575	10	0	2	11	49	371	1, 847	4, 086	4, 549	1, 641	9
	Female:												
	Underlying	67, 419	7	0	5	14	129	969	5, 589	18, 032	27, 288	15, 310	76
	Contributory	11, 629	0	0	2	2	22	182	1, 130	3, 282	4, 879	2, 118	12
420. 1	Heart disease involving coronary arteries:												
	Male:												
	Underlying	159, 919	17	6	99	971	7, 474	23, 648	41, 979	49, 040	29, 541	7, 064	80
	Contributory	47, 854	16	17	41	242	1, 141	4, 663	11, 611	16, 355	11, 131	2, 603	34
	Female:												
	Underlying	71, 313	20	6	32	153	1, 132	4, 056	12, 296	23, 878	22, 049	7, 620	71
	Contributory	29, 139	4	4	24	111	423	1, 416	4, 576	10, 219	9, 462	2, 879	21
420. 2	Angina pectoris:												
	Male:												
	Underlying	568	0	0	0	4	25	62	147	183	103	44	0
	Contributory	2, 416	0	0	0	6	73	345	743	751	431	65	2
	Female:												
	Underlying	356	0	0	0	0	2	20	59	96	124	55	0
	Contributory	974	0	0	0	0	12	36	203	326	314	81	2
421	Chronic endocarditis not specified as rheumatic:												
	Male:												
	Underlying	3, 370	31	7	6	39	96	298	633	1, 000	942	316	2
	Contributory	2, 281	9	9	9	25	49	133	382	720	715	230	0
	Female:												
	Underlying	2, 730	11	0	24	37	45	135	291	625	1, 023	539	0
	Contributory	2, 169	9	2	12	4	23	77	244	603	803	392	0
422	Other myocardial degeneration:												
	Male:												
	Underlying	25, 505	32	39	30	35	268	899	2, 573	6, 872	9, 452	5, 293	12
	Contributory	21, 431	57	26	30	119	415	1, 406	3, 862	7, 021	6, 248	2, 240	7
	Female:												
	Underlying	26, 912	22	9	13	47	171	500	1, 626	5, 453	10, 844	8, 204	23
	Contributory	15, 696	39	25	50	75	193	578	1, 757	4, 451	5, 597	2, 921	10

TABLE 2.—Number of deaths by age, sex, and selected diagnoses classified as the underlying or contributory cause of death, white population, United States, 1955—Continued

International List Nos., 7th revision	Diagnosis and sex	Total	0–4	5–14	15–24	25–34	35–44	45–54	55–64	65–74	75–84	85+	Not stated
430–434	Other diseases of heart:												
	Male:												
	Underlying	10, 643	105	47	81	151	380	1, 122	2, 092	3, 059	2, 611	976	19
	Contributory	43, 148	482	250	314	625	1, 520	3, 653	8, 486	12, 932	11, 094	3, 768	24
	Female:												
	Underlying	6, 572	60	70	41	76	220	439	854	1, 584	2, 126	1, 096	6
	Contributory	34, 377	340	218	259	490	996	2, 261	4, 497	9, 206	10, 953	5, 138	19
440–443	Hypertensive heart disease:												
	Male:												
	Underlying	26, 019	0	6	14	68	420	1, 643	4, 628	8, 286	8, 131	2, 807	16
	Contributory	19, 138	2	6	21	95	444	1, 726	4, 506	6, 624	4, 588	1, 117	9
	Female:												
	Underlying	32, 837	0	4	0	37	324	1, 466	4, 406	9, 425	12, 029	5, 109	37
	Contributory	22, 816	0	4	18	70	255	1, 154	3, 635	8, 072	7, 419	2, 174	15
444–447	Hypertension without mention of heart disease:												
	Male:												
	Underlying	4, 721	0	0	2	41	170	405	660	1, 157	1, 488	793	5
	Contributory	30, 810	4	22	102	267	893	2, 767	6, 610	10, 539	7, 720	1, 856	30
	Female:												
	Underlying	4, 325	0	0	7	56	86	173	451	999	1, 697	852	4
	Contributory	37, 405	2	7	32	195	696	2, 520	6, 232	12, 253	11, 789	3, 665	14
450	General arteriosclerosis:												
	Male:												
	Underlying	15, 096	2	0	0	5	13	161	755	2, 879	6, 471	4, 797	13
	Contributory	103, 971	0	5	8	98	860	4, 363	15, 144	33, 297	36, 637	13, 503	56

	Female:												
	Underlying	14, 840	0	0	2	6	4	52	365	2, 127	6, 070	6, 200	14
	Contributory	90, 023	15	0	4	40	263	1, 752	7, 818	24, 722	37, 362	17, 950	97
451–456	Other diseases of arteries:												
	Male:												
	Underlying	4, 664	13	9	39	54	151	532	1, 149	1, 591	898	226	2
	Contributory	7, 846	34	37	52	166	310	704	1, 588	2, 288	1, 901	766	0
	Female:												
	Underlying	2, 018	0	12	93	83	130	154	280	479	575	210	2
	Contributory	6, 632	31	22	58	134	314	538	859	1, 849	1, 992	833	2
460–468	Diseases of veins, etc.:												
	Male:												
	Underlying	2, 440	20	19	32	44	138	325	543	693	482	142	2
	Contributory	16, 459	98	67	130	319	1, 086	2, 217	4, 168	4, 665	2, 873	836	0
	Female:												
	Underlying	1, 928	13	5	23	61	105	219	358	577	416	151	0
	Contributory	12, 968	122	57	132	281	633	1, 403	2, 409	3, 780	3, 095	1, 052	4
500	Bronchitis, acute:												
	Male:												
	Underlying	492	242	17	5	5	9	24	61	54	43	30	2
	Contributory	552	77	19	2	21	9	42	111	89	133	49	0
	Female:												
	Underlying	402	188	14	0	10	11	28	6	21	70	54	0
	Contributory	442	69	21	6	4	4	31	48	60	101	98	0
501–502	Bronchitis, other:												
	Male:												
	Underlying	1, 240	178	20	4	4	29	55	254	379	234	83	0
	Contributory	2, 537	118	6	15	23	79	152	460	789	663	228	4
	Female:												
	Underlying	602	118	16	2	7	13	14	46	133	157	96	0
	Contributory	1, 067	62	19	2	18	24	56	143	223	388	130	2
525	Other chronic interstitial pneumonia:												
	Male:												
	Underlying	1, 420	294	13	6	17	47	140	299	401	176	27	0
	Contributory	2, 720	64	12	4	36	59	179	672	1, 038	555	96	5

Table 2.—Number of deaths by age, sex, and selected diagnoses classified as the underlying or contributory cause of death, white population, United States, 1955—Continued

International List Nos., 7th revision	Diagnosis and sex	Total	0–4	5–14	15–24	25–34	35–44	45–54	55–64	65–74	75–84	85+	Not stated
	Female:												
	Underlying	628	168	19	9	10	34	28	87	139	90	42	2
	Contributory	947	48	23	0	10	55	61	137	237	297	79	0
526	Bronchiectasis:												
	Male:												
	Underlying	1, 417	0	14	11	47	79	123	303	501	261	78	0
	Contributory	2, 191	15	10	15	20	60	168	500	774	507	120	2
	Female:												
	Underlying	687	9	7	8	8	51	53	110	188	187	64	2
	Contributory	826	8	14	6	17	12	43	91	284	272	79	0
527. 1	Emphysema without mention of bronchitis:												
	Male:												
	Underlying	3, 243	13	0	0	7	86	340	1, 045	1, 161	498	88	5
	Contributory	6, 857	108	4	16	21	126	470	1, 667	2, 683	1, 440	322	0
	Female:												
	Underlying	465	2	0	5	10	40	45	71	136	122	32	2
	Contributory	1, 268	78	0	7	4	34	97	188	353	369	138	0
527. 0 527. 2	Other diseases of lung:												
	Male:												
	Underlying	1, 142	723	14	20	8	19	44	77	128	73	34	2
	Contributory	7, 643	899	124	113	212	403	704	1, 486	1, 960	1, 365	371	6
	Female:												
	Underlying	688	401	8	4	17	14	27	33	76	67	41	0
	Contributory	5, 583	501	90	58	148	296	479	886	1, 357	1, 308	460	0

discarded varied widely by diagnosis. Cancer is the only disease selected as the underlying cause of more than 90 percent of the deaths for which it was stated to have contributed to death. At the other extreme is arthritis, excluding rheumatoid arthritis, chosen as the underlying cause of only 9 percent of the deaths for which it was mentioned as a cause. About one of eight diagnoses of general arteriosclerosis and hypertension without mention of heart disease was selected as the underlying cause of death.

The percentage of the total number of entries of a given diagnosis selected as the underlying cause was determined, in part, by the proportion of the total number that appeared on death certificates having only one cause of death. This information was not shown by diagnosis in the tabulation from which the data in table 1 were taken. It is known from other tabulations that only one diagnosis was coded for 42 percent of the deaths. The effect of this upon the percentages shown in table 1 is, at present, unknown. Whatever it may be, the data in table 1 clearly show that a substantial proportion of the total number of entries of many diagnoses do not appear in single-cause mortality statistics.

A type of tabulation that corrects part of the deficiencies of single-cause mortality statistics is illustrated in table 2. This is similar to a table that appears in the annual report of many national offices of vital statistics. However, instead of having only a single set of frequencies for each diagnosis, two sets are given: one showing the number of deaths for which each diagnosis was selected as the underlying cause, the other showing the number of deaths for which each diagnosis was selected as a contributory cause.

The first set of frequencies is an unduplicated count of deaths: The sum of the two sets is a count of diagnoses and shows the total number of deaths for which each diagnosis was certified as having played a part in bringing about the final outcome.

This tabulation contains all the information shown in the corresponding table prepared by many national offices of vital statistics, based on coding only the underlying cause of death, and, in addition, (*a*) represents more completely the frequency with which each diagnosis is entered on death certificates, (*b*) gives a more rational basis for judging the relative importance of various conditions as a cause of death, (*c*) greatly increases the usefulness of mortality statistics for epidemiological studies, (*d*) increases the confidence with which the international comparison of cause of death statistics may be made, (*e*) provides data for judging the effect of coding rules upon selecting the underlying cause of death, and (*f*) furnishes a measure of the effect of changes in coding rules upon the trend in the death rate from specific causes.

Although the tabulation illustrated in table 2 will correct many of the deficiences of single-cause mortality statistics pointed out in my previous note, it does not fully summarize the diagnostic information entered on death certificates. The death of many persons is brought about by the combined action of two or more diseases. The cause of death for such persons can be best represented by a composite diagnosis formed by

combining two or more diagnostic terms. For example, a death attributed to acute myocardial infarction, hypertension, and nephrosclerosis would be classified as due to the combination of these three diseases. A tabulation of combinations of selected diagnoses entered on death certificates during 1955 is now being planned; the resulting data will be presented in a subsequent note.

New Numerators for Old Denominators—Multiple Causes of Death [1]

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INTEREST in analyses of all the diagnoses reported on death certificates, rather than only the underlying or primary cause, extends back many years. Cross-tabulations of underlying and contributory or associated causes were made by the National Office of Vital Statistics and its predecessors of deaths in the United States in each of 5 years between 1917 and 1940. Several other countries tabulate the frequency of causes as underlying and as contributory, or the frequency with which selected causes occur with selected other causes on the same certificates. The Sixth Revision of the International Statistical Classification (1948) included a suggested Form of Multiple-Cause Tabulation, calling for the tabulation of the frequency with which each cause in the Intermediate List was reported as the underlying cause, as a complication of the underlying cause, and as a contributory cause. Only limited use has ever been made of any of these tabulations.

Reasons for the interest in multiple-cause tabulations have been stated many times, most recently by Dorn (*1*) and by Dorn and Moriyama (*2*). They include the following:

1. Tabulations of only a single cause cannot reflect the complicated pattern and interrelationship of diseases involved in many deaths.
2. Tabulations of a single cause discard almost half of the diagnoses reported on death certificates.
3. Rules for selection of the cause to be tabulated—the underlying cause—distort both magnitude and trends for some diseases and prevent the recognition and accurate description of emerging trends for other important diseases.

The Sixth and Seventh Revisions of the ISC included a few rubrics for deaths for which two causes were reported jointly, *e.g.*, influenza with pneumonia and hypertensive heart disease with arteriolar nephrosclerosis;

[1] Presented at the Harold F. Dorn Memorial Session on November 13, 1963, at the ninety-first annual meeting of the American Public Health Association, Kansas City, Mo.

[2] National Institutes of Health, Public Health Service, U.S. Department of Health ,Education, and Welfare

these are known as "linkage" rubrics. Several proposals for the Eighth Revision include "linkage" rubrics for many combinations of various forms of cardiovascular disease, diabetes, and bronchopulmonary disease. The Subcommittee on Classification of Cardiovascular Diseases, of the U.S. National Committee on Vital and Health Statistics, recommended that rather than building "linkage" rubrics into the classification of disease, 1) the classification be restricted to an unduplicated list of diagnoses; 2) multiple causes be coded; and 3) combinations of diseases be identified in the tabulation process. This procedure would provide greater flexibility in the search for associated causes than is possible when only selected combinations are incorporated into the classification scheme.

In 1958 the National Vital Statistics Division (NVSD), National Center for Health Statistics, undertook multiple-cause coding of deaths which occurred in the United States during the year 1955. Tabulations of these data by the National Heart Institute are the basis for this report. Twenty percent of deaths in the 15 States in the Middle Atlantic, East North Central, and West North Central Regions, and 50 percent of deaths in all other States were selected by the designation of terminal digits of certificate numbers. A total of 526,000 deaths were coded, or 34.4 percent of the total for the United States; these deaths, weighted to reflect the sampling ratios (as are all data presented here), are within 0.1 percent of the total number reported in NVSD publications. The maximum difference for any 10-year age group does not exceed 1.1 percent and for any age-color-sex group, 2.5 percent.

The NVSD developed instructions for coding multiple causes of deaths (*3*) which included the following rules:

1. The underlying cause of death was selected and coded in accordance with the procedures used for 1955 data.
2. Up to four additional causes were coded, including the immediate cause, intervening causes (between underlying and immediate), and causes shown in Part II of the death certificate as contributing to death.
3. In general, symptoms and ill-defined causes were not coded when one or more specific diagnoses were recorded.
4. A single code was assigned only once for a death.
5. If the same disease was reported twice for a death in different terms, it was coded only once; however, complications and other sequelae were coded.
6. Special rules were provided for malignant neoplasms and tuberculosis (one site only was coded), for coding both acute and chronic forms of diseases, and for coding multiple external causes.

RESULTS

Frequency of Multiple-Cause Reporting

Two or more causes were coded for 58 percent of all deaths; the proportion was 29 percent for deaths under age 5 and increased steadily with age to 72 percent for deaths at age 85 and over (table 1). The mean

number of causes coded per death was 1.91 for all ages combined; it was 1.40 for deaths under age 5 and increased to 2.11 for deaths at age 85 and over. Information is not available on the number of terms appearing on certificates but not coded because of application of the rules.

TABLE 1.—Number of deaths and number of conditions (causes) coded, by age, United States, 1955

Age	Number of deaths	Percentage distribution						Mean number coded
		Total	1	2	3	4	5	
All ages, crude	1, 527, 691	100. 0	42. 0	34. 0	17. 1	5. 2	1. 7	1. 91
Under 5	123, 826	100. 0	71. 0	20. 9	6. 0	1. 5	0. 6	1. 40
5–24	39, 312	100. 0	64. 4	25. 5	7. 5	1. 9	0. 7	1. 49
25–44	105, 443	100. 0	58. 7	27. 3	10. 0	3. 0	1. 1	1. 60
45–64	392, 530	100. 0	47. 7	31. 7	14. 6	4. 5	1. 6	1. 80
65–84	719, 073	100. 0	32. 9	37. 5	21. 0	6. 5	2. 1	2. 07
85 and over	145, 878	100. 0	28. 0	42. 0	22. 3	6. 0	1. 6	2. 11
Not stated	1, 629	100. 0	48. 9	31. 5	14. 9	3. 5	1. 3	1. 77

Table 2 shows the corresponding figures for each of the 4 color-sex groups. The percentage of deaths with two or more causes coded is higher for females than for males in each color group for all ages combined, and for each of the age groups with the exception of nonwhites in the youngest and oldest age groups. Adjustment for differences between the color-sex groups in the age distributions of decedents reduces the sex disparity in the proportion with two or more causes. Data on average number of causes coded per death show a similar pattern.

The proportion of deaths with two or more causes coded is higher for whites than for nonwhites in each sex group. The young (under 25) and old (65 and over) age groups are responsible for the color difference in the frequency of multiple causes; between ages 25 and 65 the percentages of white and nonwhite deaths with two or more causes are about equal. Data on average number of causes coded per death show a similar pattern.

Very great differences between the color and sex groups in the frequency of reporting of multiple causes would limit the interpretation of multiple-cause data, if they reflected variation in certification practice rather than color and sex differences in diseases contributing to death. There is the general impression, supported by some evidence, that a larger proportion of illness is medically attended among females than among males, and among whites than among nonwhites. More frequent multiple-cause certifications would be expected for deaths of individuals who had medical attention; thus, the differences observed are in the expected direction. Expressed as percentages of the higher figures, the deficits for males and for nonwhites are:

Contributory causes	Deficit (%) for males		Deficit (%) for nonwhites	
	White	Nonwhite	Male	Female
Percent with 1 or more	6. 9	6. 4	10. 4	10. 8
Mean number	4. 6	3. 3	6. 4	7. 6

Table 2.—Percent of deaths with two or more causes coded, and mean number of causes coded, by age for each color-sex group, United States, 1955

Age	Percent with 2 or more				Mean number			
	White males	White females	Nonwhite males	Nonwhite females	White males	White females	Nonwhite males	Nonwhite females
All ages, crude	56. 7	63. 1	45. 7	49. 8	1. 88	2. 00	1. 67	1. 74
Under 5	30. 3	31. 2	23. 8	23. 1	1. 42	1. 43	1. 31	1. 30
5–24	33. 1	42. 5	29. 1	39. 5	1. 44	1. 62	1. 37	1. 55
25–44	39. 1	44. 3	39. 0	45. 9	1. 57	1. 67	1. 55	1. 67
45–64	51. 0	54. 6	50. 0	55. 1	1. 78	1. 87	1. 74	1. 82
65–84	65. 4	70. 6	56. 8	60. 6	2. 04	2. 15	1. 86	1. 93
85 and over	71. 8	73. 2	61. 5	58. 6	2. 11	2. 13	1. 93	1. 85
Not stated	52. 5	54. 0	40. 7	50. 5	1. 83	1. 78	1. 62	1. 70
Age-adjusted*	56. 8	61. 0	50. 9	54. 4	1. 88	1. 97	1. 76	1. 82

*To the age distribution of deaths in the total population, by the direct method. Deaths with age not stated were excluded.

If the true differences in the frequency of diseases contributing to death were zero, these observed differences could be considered modest but important enough to be kept in mind, particularly for white-nonwhite comparisons.

The average number of contributory causes per death varies widely among underlying causes. It is high for diabetes, cerebrovascular disease, hypertensive disease, the diseases of the digestive and genitourinary system, chronic respiratory diseases, and accidental falls; it is low for malignant neoplasms, all diseases of early infancy, accidents other than falls, suicide, and homicide. The increase with age in average number of contributory causes reflects not only the more frequent existence of concomitant diseases but also increased representation of deaths which involve diseases with large numbers of contributory causes. The absence of a white-nonwhite differential for contributory causes at ages 25 to 64 but not at younger and older ages can be attributed in part to the fact that cerebrovascular and hypertensive diseases (high-average associated causes) account for a larger proportion, while malignant neoplasms and accidents (low-average causes) account for a smaller proportion of deaths of nonwhites than of whites at these ages. Tabulations necessary to measure the extent of this effect on the average number of contributory causes are not presently available. Also, it is likely that understatement of age is more prevalent among middle-aged nonwhites. This would tend to increase the average number of causes per nonwhite death at these ages because deaths with age understated carry with them the larger numbers of contributory causes which obtain at the older, true age.

Types of Multiple-Cause Tabulations

Several types of multiple-cause tabulations can be made. Much more exploration and intensive analyses than have been carried out to date will be required before conclusions can be drawn about their comparative values. More knowledge of the character of the cases of disease recorded as contributing to death than is presently available will aid in evaluating their usefulness.

One type of tabulation is a simple count of the frequency of a cause of death as the underlying and as a contributory cause. Information is provided on total frequency with which a particular cause is recorded, but none on association of different causes in the same deaths (*2*).

A second type of tabulation shows the number and kind of contributory causes recorded for deaths attributed to a particular underlying cause. It provides information on deaths in which two causes are associated, with or without other causes being present.[3] Deaths with more than one contributory cause appear once for each contributory cause, and the amount of duplication of deaths varies with the causes involved and the age at death.

[3] Extensive tabulations of the first and second types have been published by the National Center for Health Statistics in *Vital Statistics of the United States*, 1955 (Supplement).

A third type yields an unduplicated count of deaths classified according to specified combinations of diseases. Because of the reporting of more than two causes for some deaths, the classification must either take all possible combinations into account, which is impractical, or specify for some combinations the diseases which must not be present. The latter requires setting some order of priority for diseases. For example, if there are rubrics for coronary disease with cerebrovascular disease, and for coronary disease with congestive heart failure, instructions must provide for the unambiguous assignment of a death certificate with entries for coronary disease, cerebrovascular disease, and congestive heart failure. The mechanics of such assignments are simpler than the preparation of descriptive definitions of the contents of the resulting classification scheme. This type of tabulation is more flexible than the second type in that categories can be combined as desired without encountering distortion due to duplicate counting of deaths.

Coronary Heart Disease and Hypertensive Disease

Deaths occurring in the United States in 1955 with specified combinations of cardiovascular diseases have been tabulated (third type). Data will be presented on deaths involving coronary heart disease, or hypertensive disease, or both. Coronary disease was defined as terms coded to ISC category 420, and hypertensive disease as terms coded to ISC categories 440–447 which includes both hypertensive heart disease and hypertension without mention of heart disease. Deaths from combinations of coronary and/or hypertensive disease with cerebrovascular disease (ISC 330–334) and/or diabetes (ISC 260) were also tabulated but have been excluded to present here the least complicated pattern of association of coronary and hypertensive disease in mortality. In addition, deaths in which the underlying cause was rheumatic heart disease were excluded.

Data on coronary disease alone, on coronary and hypertensive disease coded for the same deaths, and on hypertensive disease alone are given in table 3 for white males and females, by age. The number of deaths from coronary and hypertensive disease is about the same as the number of deaths from hypertensive disease alone, for each sex. It is about one tenth of the number from coronary disease alone for white males and one fifth for white females. Corresponding data for nonwhites appear in table 4, the outstanding difference being that the number of deaths from hypertensive disease alone is more than 3 times the number for coronary and hypertensive disease and is more than half the number for coronary disease alone.

In conventional mortality statistics the rules for selecting the underlying cause provide that deaths with coronary and hypertensive disease be assigned to coronary disease; thus the categories for coronary disease and for coronary and hypertensive disease in table 3 may be regarded essentially as subdivisions of the conventional coronary disease rubric, except

TABLE 3.—Death rates for coronary disease (ISC 420) and hypertensive disease (ISC 440–447): white population, by age and sex, United States, 1955

Age	Coronary alone		Coronary and hypertensive		Hypertensive alone	
	Male	Female	Male	Female	Male	Female
Number of deaths	202, 977	100, 160	20, 292	20, 592	21, 108	23, 610
Death rates:						
Age-adjusted	285. 8	120. 7	28. 5	25. 2	30. 3	28. 3
All ages, crude	280. 3	135. 1	28. 0	27. 7	29. 2	31. 9
Under 5	0. 2*	0. 2*	—	—	—	—
5–14	0. 0*	0. 0*	—	—	0. 0*	0. 0*
15–24	1. 1	0. 4	—	—	0. 2*	0. 1*
25–34	9. 4	1. 4	0. 3	0. 1*	0. 8	0. 7
35–44	75. 6	10. 0	4. 6	1. 7	4. 4	2. 8
45–54	295. 7	44. 2	22. 3	9. 8	16. 3	9. 6
55–64	710. 8	174. 3	77. 4	49. 0	50. 4	38. 4
65–74	1, 419. 8	588. 6	167. 6	151. 7	141. 4	123. 6
75–84	2, 836. 2	1, 806. 9	277. 4	340. 3	412. 9	462. 2
85 and over	5, 025. 8	4, 152. 9	356. 8	474. 5	1, 009. 4	1, 017. 7

*Less than 20 deaths.

TABLE 4.—Death rates for coronary disease (ISC 420) and hypertensive disease (ISC 440–447): nonwhite population, by age and sex, United States, 1955

Age	Coronary alone		Coronary and hypertensive		Hypertensive alone	
	Male	Female	Male	Female	Male	Female
Number of deaths	11, 043	7, 266	1, 853	1, 854	6, 059	5, 992
Death rates:						
Age-adjusted	172. 5	108. 7	28. 8	27. 6	94. 3	88. 0
All ages, crude	128. 1	79. 6	21. 5	20. 4	70. 2	65. 7
Under 5	0. 7*	0. 6*	—	—	—	0. 2*
5–14	0. 5*	0. 2*	—	—	—	—
15–24	2. 3	2. 9	—	—	2. 6	1. 1*
25–34	13. 9	9. 1	1. 8	2. 4	9. 5	10. 4
35–44	68. 7	32. 8	10. 3	8. 1	54. 8	51. 7
45–54	231. 4	126. 5	43. 2	34. 0	127. 8	110. 0
55–64	492. 4	267. 4	93. 7	91. 9	245. 0	228. 8
65–74	850. 7	553. 2	144. 2	149. 5	424. 0	416. 8
75–84	1, 257. 9	931. 6	179. 4	172. 3	707. 8	688. 7
85 and over	1, 965. 4	1, 822. 9	192. 3	225. 7	1, 315. 4	1, 025. 7

*Less than 20 deaths.

that deaths including either cerebrovascular disease or diabetes as a contributory cause have been excluded. While little is known about the significance of diseases reported as contributory causes, it is likely that the hypertensive disease was an important factor in the deaths from coronary and hypertensive disease rather than merely asymptomatic elevation of blood pressure, for the following reasons: A substantial proportion of the deaths from coronary and hypertensive disease was probably considered by the physicians certifying the causes of death to have had hypertensive disease as the underlying cause, whereas rules for selection of underlying cause preclude such designation; for three fifths of all the deaths with hypertensive disease coded as contributory to

coronary disease, the hypertensive disease was coded as hypertensive heart disease, a distinct clinical entity.

In comparison of the age-specific death rates per 100,000 population for color-sex groups in tables 3 and 4, the rates for nonwhite males and females for coronary disease are intermediate to the high rates for white males and the low rates for white females. For coronary and hypertensive disease, the rates for nonwhite males and females are about equal and a little above the rates for both white males and females up to age 65. Rates for hypertensive disease alone are almost identical for the two sexes of each color group, but those for nonwhites far exceed those for whites.

Sex Ratios of Death Rates

The ratios of male death rates to the female rates in each age group are given in table 5 for whites and for nonwhites. For coronary disease alone, the rate for white males is about 7 times that for white females at ages 25 to 54, being highest at age 35 to 44 and declining to near unity at age 85 and over. For coronary and hypertensive disease the ratio is highest (2.7) at age 35 to 44 and drops below unity at age 75. While the sex ratios for hypertensive disease run somewhat lower, the difference is small after age 45.

TABLE 5.—Ratios of male to female death rates for coronary disease (ISC 420) and hypertensive disease (ISC 440–447): whites and nonwhites, by age, United States, 1955

Age	Whites			Nonwhites		
	Coronary alone	Coronary and hypertensive	Hypertensive alone	Coronary alone	Coronary and hypertensive	Hypertensive alone
Age-adjusted	2. 37	1. 13	1. 07	1. 59	1. 04	1. 07
All ages, crude	2. 07	1. 01	0. 92	1. 61	1. 05	1. 07
Under 5	1. 00*	*	*	1. 17*	*	*
5–14	*	*	*	2. 50*	*	*
15–24	2. 75	*	2. 00*	0. 79	*	2. 36*
25–34	6. 71	3. 00*	1. 14	1. 53	0. 75	0. 91
35–44	7. 56	2. 71	1. 57	2. 09	1. 27	1. 06
45–54	6. 69	2. 28	1. 70	1. 83	1. 27	1. 16
55–64	4. 08	1. 58	1. 31	1. 84	1. 02	1. 07
65–74	2. 41	1. 10	1. 14	1. 54	0. 96	1. 02
75–84	1. 57	0. 82	0. 89	1. 35	1. 04	1. 03
85 and over	1. 21	0. 75	0. 99	1. 08	0. 85	1. 28

*On a ratio: one or both rates based on less than 20 deaths. Alone: one or both rates zero.

The sex ratios for nonwhites are much nearer unity, with those for coronary disease being about two for age groups up to 65. The ratios for coronary and hypertensive disease and for hypertensive disease alone are roughly equal and not substantially different from unity.

Color Ratios of Death Rates

Ratios of nonwhite to white death rates for each sex are given in table 6. The color ratios, unlike the sex ratios, are low for coronary disease and extremely high for hypertensive disease, for each sex. Like the sex ratios, the color ratios for coronary and hypertensive disease fall between those for each disease alone, but are much closer to those for coronary disease than for hypertensive disease.

TABLE 6.—Ratios of nonwhite to white death rates for coronary disease (ISC 420) and hypertensive disease (ISC 440–447): males and females, by age, United States, 1955

Age	Males			Females		
	Coronary alone	Coronary and hypertensive	Hypertensive alone	Coronary alone	Coronary and hypertensive	Hypertensive alone
Age-adjusted	0. 60	1. 01	3. 11	0. 67	1. 10	3. 10
All ages, crude	0. 46	0. 77	2. 40	0. 59	0. 74	2. 06
Under 5	3. 50*	*	*	3. 00*	*	*
5–14	*	*	*	*	*	*
15–24	2. 09	*	*	7. 25	13. 00*	11. 00*
25–34	1. 48	6. 00	11. 88	6. 50	24. 00*	14. 86
35–44	0. 91	2. 24	12. 45	3. 28	4. 76	18. 46
45–54	0. 78	1. 94	7. 84	2. 86	3. 47	11. 46
55–64	0. 69	1. 21	4. 86	1. 53	1. 88	5. 96
65–74	0. 60	0. 86	3. 00	0. 94	0. 99	3. 37
75–84	0. 44	0. 65	1. 71	0. 52	0. 51	1. 49
85 and over	0. 39	0. 54	1. 30	0. 44	0. 48	1. 01

*On a ratio: one or both rates based on less than 20 deaths. Alone: one or both rates zero.

DISCUSSION

Although the consideration of interrelationships of diseases in individuals is commonplace in clinical practice, there is a paucity of data on these relationships in large population groups. Consequently there is little accumulated experience in the analysis of such data. Multiple-cause mortality data differ from the data produced by prospective studies, not only because of the inherent difference in the scope, completeness, and accuracy of the data recorded but also because they provide no information on disease in the survivors. Thus, death rates for particular causes or combinations of causes do not reflect the risk of death among persons who have the disease or diseases in question, and the temptation to so regard them must be avoided. Rather, they represent the rate at which persons die with a specified disease or combination of diseases primarily responsible for or contributing to death, in the opinion of the certifying physicians. It is necessary to look within the data themselves, at comparisons of age, sex, and color specific rates for clues about interrelationships among diseases. Like other general purpose data, they may or may not provide evidence bearing on specific hypotheses. They do, of course,

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reveal numerical relationships among rates for combinations of diseases and for diseases not usually selected as the underlying causes of death. Eventually they should be capable of producing data on time trends.

Hypertension is generally regarded as being causally associated with coronary disease, based on both clinical observation and on data from prospective studies showing an increased risk of coronary disease accompanying elevation of blood pressure. Atherosclerosis and hypertension are considered to be conducive to or to aggravate each other, even though they are separate diseases with different etiologies.

In table 7, the death rates for coronary disease, for hypertensive disease, and for coronary and hypertensive disease are expressed as a percentage of the over-all rate for selected age-color-sex groups. For white males the rates for hypertensive disease and for coronary and hypertensive disease are about equal—one twentieth of the total—while the coronary disease rate accounts for nearly nine tenths. The rate for hypertensive disease alone for nonwhite males is about three tenths of the total, much larger than for white males, but the proportionate contribution of coronary and hypertensive disease combined is not much larger than for white males. For white females the contributions for hypertensive disease alone and for coronary and hypertensive disease are about equal, and each accounts for one sixth of the total. Hypertensive disease alone for nonwhite females accounts for more than two fifths of the total, but the proportion for coronary and hypertensive disease is smaller than for white females.

Table 7.—Percent distribution of death rates for coronary and hypertensive disease, for selected age groups, by color and sex, United States, 1955

Age, color, and sex	Total: Rate	Total: Percent	Percent distribution: Coronary	Percent distribution: Coronary and hypertensive	Percent distribution: Hypertensive
White male					
35–44	84. 6	100. 0	89. 4	5. 4	5. 2
45–54	334. 3	100. 0	88. 5	6. 7	4. 9
55–64	838. 6	100. 0	84. 8	9. 2	6. 0
Nonwhite male					
35–44	133. 8	100. 0	51. 3	7. 7	41. 0
45–54	402. 4	100. 0	57. 5	10. 7	31. 8
55–64	831. 1	100. 0	59. 2	11. 3	29. 5
White female					
35–44	14. 5	100. 0	69. 0	11. 7	19. 3
45–54	63. 6	100. 0	69. 5	15. 4	15. 1
55–64	261. 7	100. 0	66. 6	18. 7	14. 7
Nonwhite female					
35–44	92. 6	100. 0	35. 4	8. 7	55. 8
45–54	270. 5	100. 0	46. 8	12. 6	40. 7
55–64	588. 1	100. 0	45. 5	15. 6	38. 9

These differences indicate that deaths of nonwhites with hypertensive disease are less likely to involve coronary disease than are such deaths of whites. The implications of this observation are not entirely clear.

One possibility is that whatever the association in mortality between hypertensive disease and coronary disease it is more pronounced for whites than for nonwhites, and for females than for males. However, each of these diseases is also a frequent factor in deaths involving another major cause—cerebrovascular disease.

The age-adjusted death rates for coronary, hypertensive, and cerebrovascular disease, alone and in combinations, are given in table 8 for each color-sex group. Death rates of nonwhites for cerebrovascular disease, alone and with hypertensive disease, are well above those for whites, for each sex, but the excess for nonwhites is much greater for cerebrovascular disease associated with hypertensive disease (2.5 to 1) than for cerebrovascular disease alone (1.33 to 1). This excess of the nonwhite over the white rate for cerebrovascular disease with hypertensive disease is of the same order of magnitude as noted for hypertensive disease alone.

TABLE 8.—Age-adjusted death rates for coronary, hypertensive, and cerebrovascular disease, alone and in combination, for each color-sex group, United States, 1955

Cause(s) of death	White males	White females	Nonwhite males	Nonwhite females
Total	482. 1	296. 3	508. 7	433. 4
Coronary alone	285. 8	120. 7	172. 5	108. 7
Coronary and hypertensive	28. 5	25. 2	28. 8	27. 6
Hypertensive alone	30. 3	28. 3	94. 3	88. 0
Coronary and cerebrovascular				
With hypertensive	4. 0	4. 1	4. 6	4. 2
Without hypertensive	18. 3	12. 6	12. 6	9. 7
Cerebrovascular and hypertensive	34. 8	40. 1	89. 8	104. 1
Cerebrovascular alone	80. 4	65. 3	106. 1	91. 1
	Percent distribution of rates			
Total	100. 0	100. 0	100. 0	100. 0
Coronary alone	59. 3	40. 7	33. 9	25. 1
Coronary and hypertensive	5. 9	8. 5	5. 7	6. 4
Hypertensive alone	6. 3	9. 6	18. 5	20. 3
Coronary and cerebrovascular				
With hypertensive	0. 8	1. 4	0. 9	1. 0
Without hypertensive	3. 8	4. 3	2. 5	2. 2
Cerebrovascular and hypertensive	7. 2	13. 5	17. 7	24. 0
Cerebrovascular alone	16. 7	22. 0	20. 9	21. 0

To summarize these observations, hypertensive disease is associated with cerebrovascular disease mortality more frequently among nonwhites than among whites; it may be associated with coronary disease mortality less frequently among nonwhites in view of the generally higher level of hypertensive disease mortality of nonwhites with or without other causes.

The foregoing represents one approach to the analysis of data on a frequently reported combination of causes of death derived from a particular type of tabulation made from death-certificate information coded according to a specific set of rules. Some observations about the steps of these processes are in order.

Attempts at analysis constantly face uncertainty about the nature, significance, and completeness of diagnostic terms recorded on certificates. Criteria should be developed, and put into practice, on the importance and

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degree of relatedness to death which should exist for conditions to be recorded in Part II of the death certificate as contributory to death but not related to the morbid sequence leading to death. Continued use of the distinction between the morbid sequence and contributory causes is probably justified.

For conditions reported as an integral part of the morbid sequence, exclusion rules for what not to code can be improved over those developed for use with the 1955 data. For example, assignment of ISC code 420.0, arteriosclerotic heart disease and 420.1, heart disease specified as involving coronary arteries for the same death may prove useful in understanding the meaning of those terms, but probably is not meaningful for studies of association of diseases. Such duplication can be selectively ignored in tabulation. The value of coding several complications of the same disease such as congestive failure and disorders of heart rhythm due to coronary heart disease is problematical. Consideration should be given to the coding of all diagnostic terms, to simplify coding instructions, and to the discarding of duplicate codes and other unnecessary combinations of codes by subsequent machine-edit.

The characteristics and advantages of various types of tabulations require further study. Experience to date clearly demonstrates the necessity for precise definition of the deaths and the causes included in a set of data and description of the method by which they were classified and tabulated. It underscores the superficiality of much of the widespread use of conventional mortality statistics by persons not well acquainted with the rules for selecting and coding the underlying cause of death. Multiple-cause data require more understanding of definition and methods by the user; their potential can best be exploited by the relatively small number of persons familiar with aspects of the preparation, registration, and processing of death certificates.

SUMMARY

A special study of mortality in the United States, in 1955, provides data on all the diagnoses recorded on death certificates, in contrast to the usual practice of tabulating one "underlying cause of death" for publications of mortality statistics. Two or more causes were coded for 58 percent of all deaths; the percentage varied with age at death, from 29 percent for children under age 5 to 72 percent for persons aged 85 and over. The age-adjusted percentage was higher for whites than for nonwhites by 6 percentage points, and was higher for females than for males by 4 points. Deaths from cardiovascular disease had multiple causes recorded more often than deaths from most other causes.

The data enable the calculation of death rates for specific combinations of causes. Rates were presented for coronary heart disease, cerebrovascular disease, and hypertensive disease, as reported alone and in combina-

tions. The sex ratios and the color ratios of death rates differed markedly among diseases and combinations of diseases reported on certificates.

Some suggestions have been made about future use of data on multiple causes of death.

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On the Significance of Cause of Death as Recorded on Death Certificates in Hiroshima and Nagasaki, Japan [1]

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In a comment on the use of mortality statistics for the purpose of assessing the relative frequencies of diseases in different countries, the Study Group of the Council for International Organizations of Medical Sciences noted that the limitation which gave rise to the greatest doubt was that accuracy of diagnosis . . . "varies from country to country and is seldom of the standard which would be required for clinical or pathological research. It has often been suggested that this limitation, alone, completely invalidates the use of mortality statistics for research purposes. There is no doubt that different standards of diagnosis can account for much of the differences recorded for certain diseases, but it is unreasonable to assume that this is always so. In fact, the accuracy of diagnosis needs to be considered in detail in relation to each disease individually. If this is done, it is found that mortality statistics may be of considerable value for some diseases, but that they are too inaccurate to be of any real value in others"(*1*).

Investigations of the accuracy of death-certificate diagnoses have been made in both the United States and Europe (*2–9*). Some of these studies have utilized hospital autopsy series, and the cause of death shown on the certificate or by clinical diagnosis can be evaluated in relation to the autopsy (*2–6*). But as Beadenkopf *et al.* (*5*) point out, diagnosis may be more accurate for persons who die in hospitals than for others, so that the applicability of the results to general mortality rates is not clear.

Moriyama *et al.* (*7, 8*) circumvented this bias inherent in hospital series by using samples of all reported deaths in the United States. The quality of the certificates was evaluated after querying the certifying physicians

[1] Work supported in part by contract AT-49-GEN-72 of the U.S. Atomic Energy Commission, and in part by the Japanese Ministry of Welfare.

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[4] We are grateful to the many pathologists who have contributed to the ABCC-JNIH autopsy series, but especially to Dr. Louis J. Zeldis, who provided both the inspiration and initiative required to organize the present autopsy research program.

Above all, we wish to acknowledge the cooperation of the people of Hiroshima and Nagasaki who have made and are making their contributions to knowledge and to the welfare of all survivors of the atomic bombings and to humanity

as to the diagnostic methods, supporting evidence, and the like. The investigators classified each certificate as to whether the diagnosis seemed unlikely, reasonable, or probable, on the basis of the kind of evidence available to the physician.

An autopsy series that at least approximates the desideratum of representativeness is being developed in Hiroshima and Nagasaki, Japan, and in this report we will describe the series and use it in a first attempt at interpretation of death certification in terms of the following questions:

1. What reliance can be placed on death certificate statements of specified causes?
2. How completely are different causes of death reported?
3. To what level of diagnostic detail is it profitable to aspire when analyzing death certificates?

MATERIAL AND METHODS

The ABCC-JNIH Autopsy Series

Since 1947, the Atomic Bomb Casualty Commission (ABCC), in collaboration with the Japanese National Institute of Health (JNIH), has been engaged in a continuing study of survivors of the atomic bombings of Hiroshima and Nagasaki. The three chief components of the present program are a mortality study (*10*) based on a sample of nearly 100,000 survivors and controls called the JNIH-ABCC Life Span Study, a pathology study (*11*) based on autopsies on deaths that occur in the mortality study, and a clinical study (*12*) which provides for biennial examination of a subsample of 20,000 persons. For operational convenience these studies are managed separately, but they are designed to be mutually supporting parts of an organic whole.

The Sample

The plan of the JNIH-ABCC Life Span Study and details of the sample have been given elsewhere (*13, 14*). Briefly, the survivors were selected from city residents who in 1950 stated that they had been in Hiroshima or Nagasaki at the time of the bomb. All were selected for the sample who were eligible and within 2,500 meters of the hypocenter. A comparison group, located within 2,500 to 10,000 meters of the hypocenter, was matched by age, sex, and city to the survivors within 2,000 (not 2,500) meters. A second comparison group, similarly matched to the survivors within 2,000 meters, consists of persons not in the cities at the time of bombing (ATB) (table 1).

Estimates of radiation dose are made in cooperation with the Health Physics Division of Oak Ridge National Laboratory, Oak Ridge, Tennessee (*15, 16*). It is believed that radiation dose was quite small beyond 2,000 meters, but the precise air-dose curves are not yet known.

TABLE 1.—Composition of JNIH-ABCC Life Span Study sample

Component	Hiroshima	Nagasaki	Total
Present in city or environs ATB*			
Less than 2,000 meters from hypocenter	21, 329	6, 801	28, 130
2,000 to 2,500 meters from hypocenter	11, 524	5, 144	16, 668
2,500 to 10,000 meters from hypocenter	21, 275	6, 742	28, 017
Not present in city or environs ATB	20, 228	6, 350	26, 578
Total	74, 356	25, 037	99, 393

*At time of bombing.

Death notification was obtained by periodic consultation of the family registers and is believed to be more than 99 percent complete (*13*). Cause of death as shown on the certificate was coded by using the 1955 revision of the International Statistical Classification (*17*), following the rules of the Division of Health and Welfare Statistics of the Japanese Ministry of Welfare.

A very great advantage obtained by basing autopsy procurement on the Life Span Study sample is that, through methods independent of the procurement effort, all deaths occurring in the sample are ascertained. Therefore, the autopsies procured can be related to a specific population matrix, and bias, if any, with respect to such factors as radiation exposure, age, sex, cause of death, and so forth can be measured explicitly. There exist few if any autopsy series for which these conditions hold.

Autopsy Procurement

The ABCC adult autopsy program began in Hiroshima in 1949 and in Nagasaki in 1951. Until early 1961, most autopsies were referred from private physicians and local hospitals. There was concentration on deaths due to malignancy and on persons who had been near the hypocenter.

Beginning in January, 1961, the program was reorganized and the procurement effort concentrated wholly on obtaining autopsies on deaths which occurred in the fixed sample for the JNIH-ABCC Life Span Study. Of the original 100,000 persons, 80,000 still resided in the two cities, the losses consisting of deaths and emigrants in about equal numbers. Because the present program is, to our knowledge, unique, it will be described briefly.

The procurement effort has three aspects:

(*a*) Rapid ascertainment of all deaths that occur in the cities
(*b*) Screening of deaths against a roster of the members of the JNIH-ABCC sample
(*c*) For deaths in the sample, consultation with the attending physician and surviving relatives of the deceased to gain permission for the autopsy.

Ascertainment.—An ABCC representative twice daily visits each of the larger hospitals, the city registration section and its branch offices, funeral

companies, and crematories to learn of deaths that have occurred. Reports of death are received directly from local clinics, welfare and social agencies, and police surgeons. Obituary notices are scanned. In 1962, with the support of the City Medical associations, in each city a Death Notification Center was established to which physicians could promptly telephone reports of death. The number of notifications received from each source during the month of January, 1963, and the average time interval from death to notification for each are shown in table 2.

TABLE 2.—Average time required for death notifications January, 1963, by source and city

City and source of notification	Number	Percent	Average time from death to notification (hr:min)
Hiroshima			
Death notification center	20	5.8	9:10
Larger hospitals	47	13.6	10:53
City registration office and its branches	154	44.6	17:48
Funeral companies	98	28.4	15:32
Crematories	9	2.6	16:47
Local newspaper	14	4.0	16:40
Others	3	1.0	11:20
Total	345*	100.0	
Nagasaki			
Death notification center	17	5.7	6:52
Larger hospitals	41	13.8	10:21
City registration office and its branches	128	43.1	17:31
Funeral companies	110	37.0	14:42
Others	1	0.4	5:00
Total	297*	100.0	

*In Hiroshima 94 cases were in the study sample; in Nagasaki, 23.

Screening.—As soon as the name, address, and date of birth of the deceased are known, a check is made to determine membership in the Life Span Study sample. Occasionally, incompleteness of notifications received from funeral companies and physicians requires further identification of the deceased, but once this information is available, determination of membership in the sample takes only 3 to 4 minutes.

Negotiations for permission to autopsy.—If the deceased is identified as a sample member, the family physician is asked to help in obtaining the family's permission for autopsy. The request for permission, in addition to the usual reasons for autopsy, stresses the points that:

1) The purpose is to gain knowledge of the late effects of radiation, which is of worldwide need because of the possible hazards accompanying increased use of atomic energy for peaceful purposes.

2) The study is collaborative and is conducted not only by ABCC but also by the Japanese National Institute of Health, the City Medical Association, the Medical School Department of Pathology, and the Red Cross and Atomic Bomb Hospitals.

The Autopsy Series, 1950–1962

During the period October, 1950, to September, 1962, 1,215 autopsies were performed on members of the sample, 1,091 at ABCC and the remaining 124 at the Hiroshima or Nagasaki Medical Schools, one of the two A-Bomb Hospitals, or at the Hiroshima Prefectural Hospital. During the 12-year period 11,151 deaths occurred in the sample, so the autopsy rate was 10.9 percent (table 3). In the first 10 years, 1950–60, the rate was only 5.9 percent, but with the introduction of the new procurement methods the rate increased to 27.5 percent in 1961 and 42.0 percent in 1962.

Autopsy rates for males and females were almost identical during each time interval but were higher in Hiroshima than in Nagasaki in 1962.

The factors of distance from the hypocenter, age at death, and place of death were all highly correlated with the probability of autopsy under the old procurement system, and for all three the biases, while not eliminated, were much reduced by 1962. Thus in 1950–60, the autopsy rate among those within 2,000 meters of the hypocenter was more than twice the rate among those not in the city, while in 1962 it was only about one third larger.

In 1950–60, persons over 70 years at death were autopsied only about half as frequently as younger persons, but by 1962 the bias was eliminated.

In the earlier period the procurement rate for hospital deaths was more than 4 times that for deaths at home: 17 percent versus 4 percent. By 1962, however, the rates were nearly equalized to 50 and 40 percent. It is of some interest that during this 12-year period the proportion of deaths in hospitals rose markedly: In the decade 1950–60, only 16 percent of deaths were in hospitals, while in 1961 it was 26 percent and in 1962, 30 percent.

During 1950–60 there was concentration of autopsy procurement on deaths believed to have resulted from leukemia or other malignancies (table 4): Almost half of the leukemia cases were autopsied, while the rate for other malignant disease was nearly 10 percent, as compared with a rate for all nonmalignant disease of less than 5 percent. By 1962, although variation in autopsy rates according to the clinical diagnosis was still present, the relative magnitude of the differences was much reduced: Even for traumatic deaths, the procurement rate had increased to nearly 29 percent, and was more than half the rate for all forms of malignancy, in contrast with the earlier decade 1950–60 when the procurement rate for trauma was less than a fifth of that for malignancy.

Previous studies of the ABCC autopsy series for the years prior to 1960 have revealed strong evidence of selection (*18, 19*), and the new procurement program was stimulated by these findings. Bias is so strong, in relation to such basic factors as distance from the hypocenter, age, place, and cause of death, as to make the series of questionable value for general epidemiologic investigation of late radiation effects.

Autopsies procured under the new, collaborative plan in 1961–62, while not entirely free of bias, are clearly much more suitable for epidemiologic

TABLE 3.—Number of deaths and percent with autopsy in the JNIH-ABCC Life Span Study sample, October, 1950 to September, 1962; by sex, city, distance from hypocenter, age at death, place of death

	Total		Period					
	Oct., 1950–Sept., 1962		Oct., 1950–Sept., 1960		Oct., 1960–Sept., 1961		Oct., 1961–Sept., 1962	
	Number of deaths	Autopsy (%)	Number of deaths	Autopsy (%)	Number of deaths	Autopsy (%)	Number of deaths	Autopsy (%)
Total	11, 151	10. 9	9, 212	5. 9	966	27. 5	973	42. 0
Sex:								
Male	5, 817	11. 4	4. 828	6. 6	491	26. 9	498	42. 8
Female	5, 334	10. 3	4, 384	5. 0	475	28. 2	475	41. 3
City:								
Hiroshima	8, 572	11. 0	7, 044	5. 6	765	27. 7	763	44. 4
Nagasaki	2, 579	10. 5	2, 168	6. 8	201	26. 9	210	33. 3
Distance from hypocenter:								
0–1, 999 meters	3, 310	14. 5	2, 734	8. 5	280	33. 9	296	51. 7
2,000+ meters	5, 412	9. 5	4, 527	5. 1	445	26. 7	440	37. 7
Not in city	2, 429	9. 0	1, 951	3. 9	241	21. 6	237	38. 0
Age at death:								
0–49	2, 148	10. 4	1, 916	7. 9	120	26. 7	112	36. 6
50–69	4, 687	12. 1	3, 910	7. 0	401	32. 9	376	43. 4
70+	4, 316	9. 8	3, 386	3. 5	445	22. 9	485	42. 3
Place of death:								
Hospital	2, 043	23. 8	1, 500	16. 8	252	35. 7	291	49. 8
Home	8, 132	8. 2	6, 883	3. 8	642	24. 6	607	40. 2
Other and unknown	976	6. 7	829	3. 3	72	25. 0	75	26. 7

TABLE 4.—Number of deaths and percent with autopsy in the JNIH–ABCC Life Span Study sample, October, 1950 to September, 1962, by underlying cause of death on death certificate

Death-certificate underlying cause (International List Nos.)	Total: Oct., 1950–Sept., 1962		Period: Oct., 1950–Sept., 1960		Oct., 1960–Sept., 1961		Oct., 1961–Sept., 1962	
	Number of deaths	Autopsy (%)	Number of deaths	Autopsy (%)	Number of deaths	Autopsy (%)	Number of deaths	Autopsy (%)
Total	11, 151	10. 9	9, 212	5. 9	966	27. 5	973	42. 0
Leukemia (204)	86	47. 7	77	46. 8	3	33. 3	6	66. 7
Other malignant neoplasms (140–203, 205)	1, 811	16. 5	1, 433	9. 4	201	35. 3	177	52. 5
Vascular lesions affecting central nervous system (330–334)	2, 201	9. 1	1, 779	3. 2	202	24. 8	220	42. 7
Diseases of circulatory system (410–468)	1, 198	10. 4	962	5. 3	115	25. 2	121	36. 4
Trauma (800–999)	744	4. 6	647	2. 2	48	12. 5	49	28. 6
All other	5, 111	10. 1	4, 314	5. 7	397	27. 5	400	40. 0

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study than the earlier series. However, the 1961–62 autopsies number only 675 of the total of 1,215 in the whole JNIH-ABCC series through 1962. In a few years, as the number of autopsies acquired under the new plan increases, for some analyses it will doubtless seem proper to exclude the earlier and more biased portions of the series. At this time, however, rather than exclude nearly half of the material, it seems preferable for our purposes to employ all the available cases. Furthermore, however high is the quality of the series pertaining to the years after 1960, it will be forever true that pathologic research may be brought to bear on the 9,212 deaths in 1950–60 only through the medium of the 540 autopsies procured in this period.

RESULTS

Accuracy of Death Certificates as to Underlying Cause

While the JNIH-ABCC autopsy series is still too small to provide evidence of the kind needed with respect to the less common causes of death, a beginning can be made at assessing the accuracy of certain stated causes in Japanese mortality statistics.

For each of the 1,215 autopsies, the reviewing pathologist selected a single principal autopsy diagnosis representing the disease entity which in his opinion was the underlying cause of death. Also coded, as contributory or accessory diagnoses, were other findings which the reviewer considered to be of importance. Malignancy was always coded, whether or not considered to be implicated in the death, as was any significant abnormality of the cardiovascular system.

A comparison of the death-certificate underlying cause with the principal autopsy diagnosis is shown in table 5. Even cursory examination of the table shows that it is meaningless to speak in general terms of the "accuracy" of death-certificate statements of cause of death. More than 90 percent of malignant neoplasms diagnosed on the death certificates were confirmed at autopsy, and more than three quarters of the autopsy-proved cases were detected by the certificates. However, the confirmation rate (proportion of death certificates confirmed by autopsy) exceeded 50 percent only for tuberculosis, malignant neoplasms, the major cardiovascular-renal diseases, ulcers, cirrhosis of the liver, cholelithiasis and cholecystitis, and trauma. Detection rates (proportion of autopsy diagnoses matched on the death certificates) exceeded 50 percent only for tuberculosis, malignant neoplasms, diabetes mellitus, major cardiovascular-renal diseases, ulcers, and trauma.

Tuberculosis

Of the 95 certificates with tuberculosis listed as cause of death, 30 were contradicted by the autopsy findings. More than half of these discrepant deaths—16—were ascribed on autopsy to malignant neoplasms,

TABLE 5.—Number of deaths assigned to various causes as death-certificate underlying cause and as principal autopsy diagnosis, and confirmation and detection rates

Cause of death (International List Nos.)	Number on death certificate (A)	Number on autopsy (B)	Number on both (C)	Confirmation rate $\frac{(C)}{(A)} \times 100$	Detection rate $\frac{(C)}{(B)} \times 100$
Tuberculosis (001–019)	95	112	65	68. 4	58. 0
Other infectious disease (020–138)	24	19	5	20. 8	26. 3
Malignant neoplasms (140–205)	338	393	305	90. 2	77. 6
Benign neoplasms (210–239)	25	11	2	8. 0	18. 2
Asthma (241)	14	3	0	—	—
Diabetes mellitus (260)	15	13	7	46. 7	53. 8
Anemia (290–293)	10	10	3	30. 0	30. 0
Major cardiovascular-renal diseases (330–334, 400–468, 592–594)	341	380	260	76. 2	68. 4
Vascular lesions of central nervous system (330–334)	201	34	20	10. 0	58. 8
Diseases of circulatory system (400–468)	125	341	81	64. 8	23. 8
Chronic and unspecified nephritis and other renal sclerosis (592–594)	15	5	2	13. 3	40. 0
Influenza and pneumonia (480–493)	36	34	7	19. 4	20. 6
Ulcers (540, 541)	19	20	11	57. 9	55. 0
Hernia and intestinal obstruction (560, 561, 570)	9	3	1	11. 1	33. 3
Gastritis, duodenitis, enteritis, and colitis (except newborn) (543, 571, 572)	21	6	1	4. 8	16. 7
Cirrhosis of liver (581)	26	39	16	61. 5	41. 0
Cholelithiasis, cholecystitis, and cholangitis (584, 585)	15	18	8	53. 3	44. 4
Symptoms, senility and ill-defined conditions (780–795)	95	10	2	2. 1	20. 0
All other diseases	98	112	29	29. 6	25. 9
Trauma (E800–E999)	34	32	23	67. 6	71. 9

of which 10 were primary malignancies of the lung or mediastinum and 5 of the gastrointestinal tract. The other 14 cases were scattered, but 7 had autopsy diagnoses of pulmonary disease: 3 cases of bronchiectasis, 2 of lung abscess, 1 of lobar pneumonia, and 1 of foreign body (nail) in the lung.

The 47 deaths from tuberculosis missed on the death certificates, but diagnosed at autopsy, were assigned by the certificates to a wide variety of causes. Nine were believed to be malignant neoplasms, but only 2 of the respiratory system. Eleven were attributed to cardiovascular disease, and 9 to one of the vague conditions in the class of symptoms, senility, and ill-defined conditions.

From the fact that 112 deaths were ascribed to tuberculosis at autopsy while only 95 were so attributed on the certificates, it can be concluded that tuberculosis mortality rates, as calculated from death-certificate statements of cause for this sample of deaths, would be low by about 15 percent, by using autopsy diagnosis as a standard.

STUDY OF CANCER AND OTHER CHRONIC DISEASES

Malignant Neoplasms

The relations between certificate and autopsy diagnoses for selected sites are shown in table 6. The autopsy confirmation and clinical detection rates have been calculated in two ways: whether the malignancy was site-specifically confirmed or detected, or whether confirmed or detected as a malignancy without regard to site. For example, of death certificates that showed malignant neoplasms of the stomach as underlying cause, 86.9 percent were confirmed at autopsy as primary stomach malignancy, although 94.4 percent were confirmed as malignancy. Of the cases diagnosed at autopsy to be deaths from primary malignancy of the stomach, only 68.9 percent were called so on the certificates, but 82.2 percent were ascribed to malignant neoplasms whether of the stomach or other sites.

These results may be compared with those reported by James, Patton, and Heslin (*2*), and by Pohlen and Emerson (*3*, *4*). James *et al.* compared death-certificate statements with cause-of-death determinations, using autopsy results from a sample of 1,889 Albany, New York, hospital deaths for 1951–52. For the whole class of malignant neoplasms there can be calculated, in our terms, a confirmation rate of 92.5 percent and a detection rate of 91.0 percent as compared with our rates of 90.2 and 77.6 percent, respectively. Pohlen and Emerson also considered hospital deaths, in the decade 1930–39, using 25,000 autopsies from various cities in New York State and in Jersey City. Their data show a detection rate for all malignant neoplasms of 88.0 percent. Both reports, therefore, show detection rates higher than those reported here. However, both groups employed only deaths in hospitals. The suspicion that either malignant disease is more likely to be detected in hospitals, or that those known to have such disease are more likely to be hospitalized, is confirmed for Hiroshima and Nagasaki by the data in table 8. Secondly, it is not at all clear from the papers cited what proportion of the physicians who filled out the original death certificates may have had available to them the results of postmortem pathological examination. Under the present system in Japan, the requirement of submission of the death certificate in order to procure a cremation permit, and the usual short interval from death to cremation effectively prevent the physician from taking advantage of knowledge gained from the autopsy when certifying the death.

Forty-one deaths were ascribed to leukemia as underlying cause by death certificates, while only 31 were so listed as principal autopsy diagnosis. Twenty-nine of these diagnoses were common. The 2 cases found at autopsy but missed on the death certificates were ascribed by them to pulmonary tuberculosis and influenza. However, the 12 cases diagnosed on death certificate and not confirmed by autopsy are not easy to interpret. Five were possibly clinical errors or leukemoid reactions since 3 were ascribed at autopsy to tuberculosis and 2 to malignant neoplasms of the stomach. However, the remaining 7 cases are in the twilight zone. In 2, the death certificate diagnosis was really correct, the autopsy diagnoses being lymphosarcoma with lymphatic leukemia and stomach ulcer in a

TABLE 6.—Comparison of death-certificate and autopsy diagnoses of malignant neoplasms in relation to selected sites

Death certificate:	Site listed	Site listed	Site listed	Other site	Not malignancy	Autopsy confirmation		Clinical detection	
Autopsy:	Not malignancy	Other site	Site listed	Site listed	Site listed	As to site	As a malignancy	As to site	As a malignancy
Site	Number of deaths					Percent			
Digestive organs and peritoneum (150–159)*	17	6	156	7	42	87.2	90.5	76.2	79.5
Stomach (151)	6	8	93	18	24	86.9	94.4	68.9	82.2
Other digestive organs and peritoneum (150, 152–159)	11	18	43	9	18	59.7	84.7	61.4	74.3
Respiratory system (160–165)	2	4	26	7	20	81.2	93.8	49.1	62.3
Breast (170)	0	0	5	1	1	100.0	100.0	71.4	85.7
Uterus (171–174)	1	5	22	2	3	78.6	96.4	81.5	88.9
Lymphatic and hematopoietic (200–205)	9	3	41	4	6	77.4	83.0	80.4	88.2
Leukemia (204)	8	4	29	0	2	70.7	80.5	93.5	93.5

*International List Numbers in parentheses.

patient with leukemia. In 3 cases the "error" in the death certificate was marginal, the autopsy diagnoses being myelofibrosis with myeloid metaplasia. In the remaining 2 cases, the discrepancies, although somewhat greater, are understandable. One was diagnosed at autopsy as reticulum cell sarcoma, the other as a refractory anemia of undetermined etiology.

The situation is too complicated to be summarized in one or two numbers. However, it seems plain that the death-certificate diagnoses were not seriously in error. Of the 31 cases designated as leukemia in the principal autopsy diagnosis, 93.5 percent were so detected by the death certificates, only 2 being outright errors. Of the 41 cases designated by the death certificates, 70.7 percent were confirmed by the principal autopsy diagnosis, and of the 12 "overdiagnosed" cases, in at least 5, review of the autopsy protocol revealed that the diagnosis was essentially correct. If these 5 cases are added to the "confirmed" total, the confirmation rate rises to 82.9 percent.

Leukemia has, of course, long been identified as a late effect of radiation in Hiroshima and Nagasaki (*20*). There is much interest in these cities among the general public and the medical profession in late radiation effects, and it seems reasonable to assume that physicians are particularly alert to the detection of leukemia. It would be unjustified, therefore, to attempt to generalize to all Japan the high detection rate for leukemia reported here.

Because stomach cancer is considered to be the most frequent form of malignancy in Japan, it might be that this disease would tend to be overdiagnosed on death certificates. However, this seems to be untrue. The 135 primary malignancies of the stomach diagnosed at autopsy constituted 40 percent of all malignancies other than lymphatic and hematopoietic. However, only 107 deaths were attributed to this cause on the death certificates.

There was some confusion on certificates between stomach cancer and malignancies of other digestive organs. Of the 42 stomach cancers missed on the death certificates, 14 were called malignancies of other digestive organs, often the liver, 4 were diagnosed as malignancies of other sites, and 24 were not called malignancies at all and were ascribed to a wide variety of causes: 3 to tuberculosis, 5 to cerebral vascular disease, 2 to arteriosclerotic heart disease, only 3 to stomach ulcers, 2 to liver disease, and 1 to ulcerative colitis. Two were called simply "senility."

Of the 14 cases designated as stomach cancer on the certificates and not confirmed by autopsy, 8 were diagnosed by the pathologist as malignancies of other sites: 4 of the pancreas, 2 of the biliary passages and liver, 1 of the prostate, and 1 of generalized carcinomatosis. Only 6 cases were not diagnosed at autopsy as malignant disease, including 2 cases of stomach ulcer, 1 of cirrhosis of the liver, 2 of tuberculosis, and 1 of a foreign body in the lung.

There were 18 deaths diagnosed as malignant neoplasms of other digestive organs at autopsy and not called malignancies by the death certificates. Five or nearly a third of these were diagnosed as liver

disease on the certificates and 1 as ulcerative colitis. Three deaths were attributed to senility and 2 to tuberculosis.

The only other malignant neoplasms that were frequently ascribed on death certificates to nonmalignant disease were those of the respiratory system. Just half of the 20 missed cases were diagnosed as tuberculosis.

Breast cancer and malignancies of the uterus, as might be expected because of accessibility, were well diagnosed. However, the relatively few malignant neoplasms of the ovary were diagnosed correctly less than half the time.

From these data, it follows that vital statistics mortality rates *for the sample of deaths considered* would vary from rates based on autopsy diagnoses as follows:

All malignancies	14 percent too low
Digestive organs	13 percent too low
Stomach	21 percent too low
Other digestive organs	3 percent too high
Respiratory system	40 percent too low
Uterus	4 percent too high

The hazard involved in extrapolation from so special a sample in two particular cities is obvious, but the implication is plain, in particular, that the high mortality attributed to malignancy of the stomach in Japan may even be an understatement of the real situation.

Cardiovascular Disease

The problem of assessing the validity of medical certifications of deaths due to cardiovascular disease has recently been considered by Moriyama *et al.* (*8*), who came to the conclusion that the very concept of an underlying cause of death may be inapplicable to the class of cardiovascular-renal diseases. They estimated that for only about 75 percent of deaths ascribed to this class in the United States is it at least a reasonable inference that assignment to the class is correct, let alone assignment to a specific entity such as arteriosclerotic heart disease. The reasons given for the difficulties are twofold: First, that disease of the cardiovascular system usually occurs, not as a single diagnostic entity but as a complex of diseases; and second, that many deaths from these diseases occur suddenly and there is a lack of adequate antemortem information.

In a similar vein, Dawber and Kannel (*21*) ask the question whether coronary heart disease is an entity which can be studied by epidemiologic methods, and, while not necessarily answering the question in the negative, do assert that vital statistics pertaining to coronary heart disease are not sufficiently meaningful to warrant their use in epidemiologic studies.

An additional methodologic complication besets the present study, beyond those mentioned by Moriyama *et al.*: that our method of study is the comparison of the judgments of clinicians and pathologists who,

TABLE 7.—Comparison of underlying cause on death certificates and principal autopsy diagnoses for cardiovascular disease

International List Nos.	Death-certificate underlying cause	Total	Principal autopsy diagnosis									
			330–334	400–402	410–416	420–422	430–434	440–447	450	451–456	460–468	Other
	Total	1, 215	34	1	24	38	8	154	106	8	2	840
330–334	Vascular lesions of central nervous system	201	20		4	7		83	47	6	1	33
400–402	Rheumatic fever	1						1				
410–416	Chronic rheumatic heart disease	9			5			3				1
420–422	Arteriosclerotic and degenerative heart disease	61	2		9	13	3	3	8	1		22
430–434	Other disease of heart	18		1	1	1	1	3	2			9
440–447	Hypertensive disease, with or without mention of heart	28	1			2		17	3			5
450	General arteriosclerosis	6						1	1			4
451–456	Other arterial disease	1						1				
460–468	Diseases of veins and other circulatory system disease	1						1				
	Other, not cardiovascular	889	11		5	15	4	41	45	1	1	766

typically, if our data are any guide, seem to be concerned primarily with different aspects of these diseases. The pathologist is interested in the underlying general process while the clinician who completes the death certificate fixes his attention on the dramatic episode which, like cerebral hemorrhage, so often leads to death. These relationships appear clearly in table 7, a cross-tabulation of underlying cause and principal autopsy diagnosis.

Nearly two thirds of the death-certificate diagnoses in this entire class of diseases (201 out of 326) were of vascular lesions of the central nervous system. Usually, indeed, the diagnosis was of cerebral hemorrhage, but because the attending physician is unlikely to be able to distinguish with precision between cerebral embolism or thrombosis and hemorrhage, it seems best to consider the group of cerebral vascular lesions together. The autopsy diagnoses, on the other hand, were concentrated in the categories of hypertensive disease and general arteriosclerosis, no less than 70 percent of the 375 principal diagnoses of cardiovascular disease being in these two categories.

It does not seem possible to us at the present time to approach directly the question "Of what did these people really die?" This question presupposes some general agreement as to the proper categories to employ, and as Moriyama *et al.* (*8*) have indicated, there is considerable doubt whether the rubrics of the 1955 revision of the International Classification of Diseases provide an adequate nosological system for cardiovascular disease. This problem is basic and requires solution before it is really fruitful to approach the simpler questions of whether the clinician was well informed of the nature of the disease in any particular instance. It is necessary to know what correct classification is before attempting to decide whether a physician has accomplished it.

Nevertheless, some indirect evidence of importance can be adduced. One question of great interest is that of the relative importance of cerebral vascular disease (CVA) and coronary heart disease (CHD) as causes of death. The death certificates attributed 201 deaths to CVA (rubrics 330–334) and only 61 to arteriosclerotic and degenerative heart disease (rubrics 420–422) which includes CHD (420). Thus, on the death certificates, CVA was more than 3 times as frequent as CHD. On the other hand, for the United States in 1960, the death rate from CVA was less than two fifths that from CHD (*22*). It is important to decide to what degree this large difference may be real and not merely a reflection of differing customs among physicians.

First, we may note that the sample of deaths considered here seems typical for Japan in the ratio of CVA to arteriosclerotic heart disease: The ratio is 3.3 to 1, while for all Japan in 1960, the ratio of mortality rates was 160.7 to 49.9 or 3.2 to 1 (*23*). We are not, therefore, dealing with a purely local phenomenon.

Second, we can ask whether CVA is really as frequent as the certified causes appear to imply. Only 20 of 201 such diagnoses, or 10 percent, were confirmed at autopsy as principal diagnosis. However, 130 or 65

percent of these were called either hypertensive disease (440–447) or generalized arteriosclerosis (450) as principal autopsy diagnosis, and in 93 percent of these cases a contributory autopsy diagnosis of CVA was present. If these be considered confirmed cases, the proportion confirmed turns out to be at least 70 percent.

Third, we may inquire as to the frequency with which CVA or CHD appeared among the autopsy diagnoses, whether principal or contributory, restricting attention to the 375 autopsies in which any cardiovascular condition was listed as the principal diagnosis. In 244 of the 375 autopsies, or 65 percent, CVA was listed, while CHD was registered in only 88 autopsies and other arteriosclerotic and degenerative heart disease (421, 422) in another 46. Thus, within the autopsy diagnoses, the ratio of CVA to CHD is 2.8 to 1 and the ratio to all arteriosclerotic and degenerative heart disease is 1.8 to 1. These ratios are, of course, smaller than corresponding ratios based on underlying cause of death in Japan, but are quite different from what might be expected on the basis of U.S. mortality data.

Finally, we may inquire as to the pathologists' designation of the immediate cause of death. When he could do so, the pathologist indicated his belief that one of the autopsy diagnoses was the immediate cause. More than a third of the immediate causes were respiratory conditions, especially bronchopneumonia, but subarachnoid hemorrhage was listed 16 times, cerebral hemorrhage 58 times, and emboli, thrombi, and other vascular lesions of the central nervous system 16 times, for a total of 90 in which CVA was noted as the immediate cause of death. In only 20 cases was CHD designated and only 26 were placed in the whole class of arteriosclerotic and degenerative heart disease. The ratio, then, is 90 to 26 or 3.5 to 1, not very different from the ratios based on the death-certificate statements of underlying cause.

It seems reasonable to conclude, therefore, that in Japan deaths from CVA probably do outnumber deaths from CHD by a factor of the order of 2 or 3 to 1, and that the explanation for the difference between Japanese and U.S. mortality patterns is not to be found in erroneous certifications in Japan, although, to be sure, local customs in both countries may tend to exaggerate the difference.

Trauma

It might be supposed that there would be few discrepancies with regard to deaths from trauma (800–999), yet the detection rate was only 68 percent and the confirmation rate only 72 percent. There were 11 deaths assigned to traumatic causes by the death certificates, but not by the autopsy. Actually, in 9 of the 11, there was no question but that trauma had immediately precipitated death (6 suicides, 1 fall, 1 drowning, 1 therapeutic misadventure), but the pathologist selected as principal diagnosis a condition such as malignancy or mental disorder that he considered the underlying disease leading to the final traumatic episode.

For all 11 cases, the death-certificate attribution to trauma was correct under the rules for selecting cause of death in the presence of joint causes.

There were 9 deaths ascribed to trauma by the autopsy, but not by the death certificate. These were all really traumatic deaths, and included such instances as a foreign body (nail) in the bronchus mistaken for tuberculosis. However, not all discrepancies resulted from mistakes. One instance was an 80-year-old female who incurred several fractures in a fall, and died 1 week later of bronchopneumonia. The attending physician knew all the facts, but chose to designate senility as the underlying cause of death.

Factors Related to the Accuracy of Certification

It may be assumed that the accuracy of certification depends upon many factors: the age and perhaps the sex of the decedent, the level of medical care available, and so forth. The influence of some of these factors is shown in table 8 for deaths due to tuberculosis and malignant neoplasms, excluding leukemia. Leukemia has been excluded because of the previously mentioned special interest in this disease in Hiroshima and Nagasaki.

For the two diseases considered, differences in accuracy of diagnosis are not large in relation to sex, city, or distance from the hypocenter. However, detection rates for both diseases are lower for older persons than for the young. This results, no doubt, in part from a tendency to ascribe deaths in older people to vague causes like "senility," but also from the fact that in older persons, diagnosis is made difficult by the presence of multiple chronic diseases. The decline in the detection rate with advancing age is much sharper for tuberculosis than for neoplastic disease, and for tuberculosis the confirmation rate also falls sharply, whereas for neoplasms the confirmation rate seems to be essentially independent of age. A distinctly encouraging feature of the data is that while tuberculosis, taken as a whole, is marked by only mediocre confirmation and detection rates, both rates are high for deaths below age 50, and hence vital statistics death rates for this disease at ages up to 50 are presumably fairly accurate.

Interestingly, the practice of ascribing deaths in elderly persons to senility is time-hallowed: John Graunt complained 300 years ago of the tendency to ascribe deaths above 60 years simply to "age" (*24*). Graunt, however, remarked that "Moreover, in case a man of seventy five years old died of a Cough . . . I esteem it little errour (as to many of our purposes) if this Person be . . . reckoned among the Aged, and not placed under the Title of Coughs." That is, the importance of errors of various kinds depends on the purpose to which the data are put.

It seems rather puzzling that although the detection rates for both diseases are higher for deaths in hospitals than for those at home, the confirmation rates are no better for hospital deaths than others—in fact, a little worse. There is no need to speculate on the reasons for this curiosity, but it should be observed that many persons who die at home have previously been studied in hospitals and are returned home for terminal care.

STUDY OF CANCER AND OTHER CHRONIC DISEASES

TABLE 8.—Comparison of death-certificate and autopsy diagnoses of tuberculosis and malignant neoplasms (excluding leukemia) in relation to city, sex, distance from hypocenter, age at death, place of death, time period

	Tuberculosis (001–019)*				Malignant neoplasms excluding leukemia (140–203, 205)			
	Number of diagnoses		Percent of:		Number of diagnoses		Percent of:	
	Death certificate	Autopsy	Confirmation	Detection	Death certificate	Autopsy	Confirmation	Detection
Total	95	112	68.4	58.0	298	362	91.6	75.4
Sex								
Male	60	68	70.0	61.8	161	187	88.8	76.5
Female	35	44	65.7	52.3	137	175	94.9	74.3
City								
Hiroshima	56	71	67.9	53.5	232	280	93.1	77.1
Nagasaki	39	41	69.2	65.9	66	82	86.4	69.5
Distance from hypocenter								
0–1,999 meters	39	46	66.7	56.5	110	131	92.7	77.9
2,000+ meters	39	47	69.2	57.4	131	164	93.1	74.4
Not in city	17	19	70.6	63.2	57	67	86.0	73.1
Age at death								
0–49	45	51	88.9	78.4	41	49	95.1	79.6
50–69	37	40	48.6	45.0	187	211	89.8	79.6
70+	13	21	53.8	33.3	70	102	94.3	64.7
Place of death								
Hospital or clinic	55	52	65.5	69.2	177	198	89.8	80.3
Home or other	40	60	72.5	48.3	121	164	94.2	69.5
Time period								
Oct., 1950–Sept., 1955	19	23	78.9	65.2	44	55	88.6	70.9
Oct., 1955–Sept., 1960	43	47	65.1	59.6	90	114	91.1	71.9
Oct., 1960–Sept., 1962	33	42	66.7	5.24	164	193	92.7	78.8

*International List Numbers are in parentheses.

Finally, it would appear that over the 12-year period considered here, the quality of diagnosis with respect to tuberculosis has been declining, but has not declined with regard to malignancy—in fact, appears to have improved. The declining quality of diagnosis of tuberculosis may well result from the sharp decrease in the annual number of deaths from this disease in recent years (*23*). Between 1950 and 1960, the crude death rate from tuberculosis in Japan declined from 146 per 100,000 to 34. In 1950, more than 1 death in 8 was ascribed to tuberculosis, while in 1960 it was less than 1 in 22. Moreover, since the decline was much greater at younger ages, there has been a pronounced shift of tuberculosis deaths toward the older ages, beset by many ills, leading to increasing difficulty in correctly distinguishing deaths due to this cause.

SUMMARY

The JNIH-ABCC Life Span Study sample and the methods of procuring autopsies on deaths that occur within members of the sample are described. The composition of the autopsy series of 1,215 through September, 1962, is considered in relation to the factors of sex, city, distance from hypocenter, age, place and cause of death, and bias in relation to these factors is measured.

Correspondence between underlying cause of death as shown on the death certificate and autopsy diagnosis is calculated. Agreement is good with respect to deaths from malignant neoplasms, and with respect to the major cardiovascular-renal diseases considered as a class. Leukemia was well diagnosed on the certificates, as were malignant neoplasms of the digestive organs, breast, and uterus. Because of difficulties inherent in the application of an unsuitable system of rubrics to deaths from cardiovascular disease, it was not possible to obtain definite results with respect to cerebrovascular disease or coronary artery disease, but indirect evidence is adduced which implies that the certified causes are probably reasonably reliable at least with regard to the relative importance of these two classes of cardiovascular disease.

Most forms of malignant disease, even primary malignancy of the stomach, are underdiagnosed on death certificates and the true mortality rates from these diseases, with particular exceptions, are probably underestimated by vital statistics death rates.

It is indicated that diagnosis of tuberculosis on death certificates has, within recent years, become increasingly unreliable probably because of the decreasing number of such deaths coupled with a shift toward the older ages. However, accuracy of diagnosis with respect to malignancy has apparently increased.

Lastly, although diagnoses made in hospitals of death due to tuberculosis or malignancy are no more reliable than those made on deaths at home, these diseases, if present, are more likely to be detected when the death occurs in a hospital.

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U.S. GOVERNMENT PRINTING OFFICE: 1965

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service